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Ground Cloud Dispersion Measurements During the Titan IV Mission A-18 (23 October 1997) at Vandenberg Air Force Base

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Environmental Systems Directorate
Systems Engineering
Space Launch Operations

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Launch Programs
SPACE AND MISSILE SYSTEMS CENTER
AIR FORCE MATERIEL COMMAND
2430 E. El Segundo Boulevard
Los Angeles Air Force Base, CA 90245

Space Systems Group

THE AEROSPACE CORPORATION
El Segundo, California

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David E. Painter, Capt, USAF
Chief, Titan Systems and
Environmental Engineering

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13. ABSTRACT (*Maximum 200 words*)

This report presents plume imagery documenting the development and dispersion of the Titan IV A-18 launch ground cloud at Vandenberg AFB at 1932 PDT on 23 October 1997. Also presented are pertinent meteorological data from towers, Doppler radar, and rawinsonde balloons. IR cameras at three locations tracked the trajectory of the launch cloud for 1.25 to 4.5 min after launch. Meteorological data were collected to improve understanding of cloud dispersion and provide inputs during model simulations/evaluations.

These data and similar data on other Titan IV launches will be used to determine the accuracy of atmospheric dispersion models such as REEDM (Rocket Exhaust Effluent Diffusion Model) in predicting toxic hazard corridors at the USAF Ranges. Imagery showed that the bottom edge of the launch cloud stabilized at 197m AGL by 3.5 min after launch, versus a predicted 250m AGL. The air entrainment coefficient was 0.39, smaller than the 0.64 default used in REEDM. Two HCl detectors were placed on a ridge at 170° azimuth from the pad, in an early predicted path of the cloud. However, the REEDM predicted a track to the east, which was realized. It therefore did not pass over the detectors, and no HCl was detected.

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Preface

The Air Force Space and Missile Systems Center's Launch Programs Office (SMC/CL) is sponsoring the Atmospheric Dispersion Model Validation Program (MVP). This program is collecting launch cloud dispersion data that will be used to determine the accuracy of atmospheric dispersion models, such as REEDM, in predicting toxic hazard corridors at the launch ranges. This report presents launch cloud dispersion and meteorological measurements performed during the Titan IVA-18 launch at Vandenberg Air Force Base on 23 October 1997.

An MVP Integrated Product Team (IPT) led by Capt. Bill Kempf (SMC/CLTE) is directing the MVP effort. Dr. Bart Lundblad of The Aerospace Corporation's Environmental Systems Directorate (ESD) is the MVP technical manager. This report was prepared by Mr. Norm Keegan (ESD) and Dr. Lundblad from materials contributed by personnel participating in the A-18 launch cloud dispersion measurements.

Infrared imagery measurements were made of the launch cloud by Ms. Karen Foster, Mr. Brian Kasper, Mr. Bruce Rockie, Dr. Don Stone, and Mr. Jess Valero of The Aerospace Corporation's Environmental Monitoring and Technology Department (EMTD). Mr. Jim Kephart of Aerospace's Western Range Directorate coordinated camera site selection and logistical support. Ms. Foster digitized the imagery data for analysis by Dr. Robert Abernathy (EMTD). The description of the cloud imagery results was prepared by Dr. Abernathy.

The deployment, operation, and data analysis for the two HCl detectors sited along Honda Ridge Road were accomplished by Dr. Bruce Weiller and Dr. Lawrence Wiedeman of Aerospace's Materials Processing and Evaluation Department.

The meteorological data displayed in this report was provided by Capt. Cynthia Koch of the VAFB Weather Squadron (30WS/DOS).

The Titan IVA-18 mission was the twelfth Titan IV launch for which usable launch cloud dispersion data was collected by MVP. The previous missions were K-7, K-23, K-19, K-21, K-15, K-16, K-22, K-2, K-13, B-24, and B-33.

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Executive Summary

This report presents plume imagery documenting the development and dispersion of the Titan IVA-18 launch ground cloud at Vandenberg Air Force Base (VAFB). The launch occurred on 23 October 1997 at 1932 PDT. The report also presents results from limited ground-level hydrogen chloride (HCl) monitoring, as well as pertinent meteorological data taken from towers, acoustic sounders (sodars), and rawinsonde balloons.

The imaging team used infrared cameras at three locations around the launch site (SLC-4E) to track the trajectory and time evolution of the vehicle's exhaust ground cloud for 1.25–4.5 min following launch. Subsequent imagery of the cloud was obscured by atmospheric clouds. Meteorological data were collected to improve understanding of cloud dispersion and to use as input during model simulations and evaluations. Rawinsonde balloon data from shortly before launch, sodar data from shortly before and after launch, and meteorological tower data from shortly before and after launch were collected and archived. These data and similar data on other Titan IV launches (past and future) will be used to determine the accuracy of atmospheric dispersion models such as the Rocket Exhaust Effluent Diffusion Model (REEDM) in predicting toxic hazard corridors (THCs) at the USAF Eastern and Western Ranges. These THCs assess the risk of exposing the public to HCl exhaust from solid rocket motors or hypergolic propellant vapors accidentally released during launch operations.

Reduction of available imagery data (from the first 1.25–4.5 min following launch) yielded limited information on cloud rise and dispersion. The imagery showed that the bottom edge of the launch cloud stabilized at an altitude of 197 m AGL by 3.5 min after launch. REEDM 7.08 predicted that the bottom edge of the launch cloud would stabilize at 250 m AGL. The bottom of the actual launch cloud therefore stabilized 21% lower than predicted by REEDM 7.08. Analysis of the imagery also showed that the rising cloud had an air entrainment coefficient (ratio of increase in diameter to increase in altitude) of 0.39. This is 39% smaller than the default air entrainment coefficient of 0.64 that is used in REEDM 7.08. The initial cloud radius extrapolated from the imagery was 198 m. This is 175% larger than the default value (72 m) used in REEDM 7.08.

Two HCl detectors were operated on a ridge top approximately 5 km from SLC-4E on an azimuth of 170° from SLC-4E. REEDM predicted that the ground cloud would travel on a trajectory of 144° and pass to the east of the detectors. Neither HCl instrument detected any HCl from the ground cloud.

1. Introduction

Launch vehicles that employ solid propellant rocket motors release exhaust ground clouds containing large quantities of hydrogen chloride (HCl) into the launch areas at Cape Canaveral Air Station (CCAS) and Vandenberg Air Force Base (VAFB). Large quantities of hazardous liquid fuels and oxidizers could also be released as a result of propellant transfer accidents or launch vehicle failures. The Air Force uses atmospheric dispersion models to predict the downwind diffusion and concentration of toxic launch clouds. Collection of launch cloud data is required to test and validate the performance of these dispersion models.

The Air Force range safety organizations at Patrick Air Force Base (45 SW/SE) and VAFB (30 SW/SE) are responsible for assuring that launches occur only when meteorological conditions will not expose nearby public areas to hazardous levels of launch exhausts and propellant vapors. Predictions of toxic hazard corridors that extend into public areas can lead to costly launch delays. The use of non-validated models requires the use of conservative launch criteria. The development and validation of more accurate atmospheric dispersion models is expected to increase launch opportunities and significantly reduce launch costs. The Space and Missile Systems Center's Launch Programs Office (SMC/CL) established the Atmospheric Dispersion Model Validation Program (MVP) to collect launch cloud data and to use the data to test and validate current and future atmospheric dispersion models at the ranges.

The MVP effort involves the collection of data during Titan IV launches at CCAS and VAFB to characterize HCl launch cloud rise, growth, and stabilization, as well as launch cloud transport and diffusion. These data, along with data collected during tracer gas releases, will be used to determine the capability of the Rocket Exhaust Effluent Diffusion Model (REEDM) to predict toxic hazard corridors at the ranges. REEDM is used at CCAS and VAFB to predict the locations of toxic hazard corridors in support of launch operations. It is applied to large heated sources of toxic air emissions such as nominal launches, catastrophic failure fireballs, and inadvertent ignitions of solid rocket motors. It uses launch vehicle and meteorological data to generate ground-level concentration isopleths of HCl, hydrazine fuels, nitrogen dioxide, and other toxic launch emissions. Launch holds may occur when REEDM toxic concentration predictions exceed adopted exposure standards. REEDM is a unique and complex model based on relatively simple modeling physics. It has a long development history with the Air Force and NASA, but has never been fully validated. Validation of REEDM has been identified as a range safety priority.

The MVP has been organized and is being directed by the MVP Integrated Product Team (IPT). SMC/CL is serving as the IPT leader, while The Aerospace Corporation's Environmental Systems Directorate serves as the IPT technical manager. The IPT consists of personnel with expertise in atmospheric dispersion modeling, meteorology, and atmospheric dispersion field studies. MVP participants include personnel from SMC, 30 SW, 45 SW, Armstrong Laboratory, The Aerospace Corporation, NASA, NOAA, and contractors. Key functions include program planning, field data collection, data review and compilation, range coordination, and model validation.

This report presents the results of measurements performed at VAFB during the Titan IVA-18 launch on 23 October 1997 at 1932 PDT. Infrared camera imagery of the ground cloud was collected from three locations to monitor the cloud's growth, stabilization, and trajectory. The imagery results are presented in Section 2. Two HCl detectors operated at a location along Honda Ridge Road on south VAFB. As reported in Section 3, neither instrument recorded any HCl following the launch. REEDM predictions of ground cloud stabilization heights and surface concentrations are presented in Appendix A. Measurements of meteorological data are tabulated in Appendix B.

A low layer of atmospheric clouds prevented imagery of the rise of the top of the cloud to its stabilization height. The cloud rose at a linear rate with time until the top of the cloud penetrated the low-lying atmospheric clouds at 1.25 min after the launch. The bottom of the cloud was tracked through 4.5 min and stabilized at 197 m AGL by 3.5 min after launch. The imagery-derived cloud bearing was similar to the T-0.7 h rawinsonde winds and to the T-0.7 h REEDM predictions. However, the imagery documented several differences between the ground cloud and REEDM predictions: (1) the imagery-derived stabilization height (197 m AGL) for the bottom of the cloud is 21% lower than predicted (250 m AGL), (2) the imagery-derived entrainment coefficient (0.39) is 39% smaller that REEDM's default value (0.64), and (3) the imagery-derived extrapolated initial cloud radius (198 m) is 175% larger than REEDM's default value (72 m). The imagery results presented in this, as well as other MVP reports, will allow the accuracy of REEDM and other launch range atmospheric dispersion models to be determined over the range of possible meteorological conditions.

2. Imagery of the Titan IV A-18 Ground Cloud

[The material in this section was contributed by R. N. Abernathy, K. L. Foster, and B. P. Kasper of the Surveillance Technology Department of The Aerospace Corporation's Space and Environment Technology Center.]

2.1 Background

The Titan IVA-18 successfully launched from Space Launch Complex 4E (SLC-4E) at Vandenberg Air Force Base (VAFB) at 19:32 PDT on 23 October 1997 (02:32 GMT on 24 October 1997). This section describes the quantitative exhaust cloud imagery data collected by imagery sites during the 4.5 min immediately following the launch from SLC-4E. This section also describes the data acquisition hardware and analysis software. The two-dimensional cloud images obtained by two of the imagery sites were combined to produce stereoscopic 3-D information. This analysis yielded the cloud's rise rate, expansion rate, speed, and bearing during the first 1.25 to 4.5 min after launch. The top of the cloud was obscured from view by low-lying atmospheric clouds after 1.25 min. However, the bottom of the cloud was tracked until 4.5 min after launch and stabilized at a height of 197m AGL by 3.5 min.

The quantitative imagery-derived ground cloud data are reported here in several graphical formats to facilitate comparison with REEDM predictions (Appendix A) and rawinsonde sounding data (Appendix B). For clarity, this section includes some data from the appendices. It is apparent from review of this section, that these data are useful for validating current and future dispersion models.

The purpose of this report was to document the quality and quantity of the A-18 exhaust cloud imagery data available for validating dispersion models. To facilitate the comparison of these data to individual dispersion model runs, the imagery-derived A-18 exhaust cloud data are available as comma-separated-variable files providing time and position for various ground cloud features. When collected, the raw visible imagery data are archived on VCR tapes. The raw infrared (IR) imagery is archived on DAT. The selected IR images analyzed for this report are also archived on magneto-optical disks as digital image files.

2.2 Introduction

This section summarizes the results of quantitative IR imagery of the exhaust cloud from the Titan IV A-18 launch from SLC-4E at VAFB on 23 October 1997 at 1932 PDT (0232 GMT on 24 October 1997). Personnel from the Aerospace Corporation's Surveillance Technology Department (STD) supported this launch with the deployment of three complete platforms of the Titan IV dedicated Visible and IR Imaging System (VIRIS). For the A-18 early evening launch, the IR imagery permitted the post-launch quantitative analysis of the ground cloud's movement and growth as a function of time.

The imagery sites chosen for the A-18 launch were

- on the road to the Spin Test Facility (STF Site)
  (788 m east and 5517 m north of SLC-4E),

- in the field southeast of Building 900 (Bldg 900 Site)
  (2916 m east and 3515 m north of SLC-4E),

- off of Santa Ynez at Geodetic Marker MOTU 4 (MOTU Site)
  (5155 m east and 1514 m north of SLC-4E).

Each site recorded only IR imagery of the exhaust cloud since it was too dark for visible imagery. Technical difficulties prevented the quantitative analysis of the Building 900 imagery. Low-lying atmospheric clouds prevented imagery of the rise of the top of the cloud to its stabilization height. Therefore, the top and middle of the cloud were only tracked till 1.25 min after launch. The bottom was tracked for 4.5 min.

The IR imagery was digitized by the AGEMA scanner at 13 bits by an internal A/D converter. Due to a bug in the acquisition program, only the least significant six bits (i.e., the intensity was "folded" to six bits of intensity) were stored to hard disk. In addition, the acquisition program averaged 7 images of the cloud with 5 unrelated images. As a result of these errors, the analyst had to subtract previous or subsequent images to reveal cloud details. Luckily, the 5 unrelated images were identical and were completely eliminated by image subtraction. In addition, the image subtraction removed some of the elevation-dependent atmospheric radiance gradient. Interestingly, the "folded" and background subtracted imagery revealed all of the ground cloud with a single intensity span. Normally, one can only view a portion of the 13 bits of intensity spanned by the ground cloud and the elevation-dependent atmospheric radiance. A down side to the image subtraction was that the exhaust cloud was in all imagery subsequent to launch. Therefore, the processed images can contain both positive and negative images of the ground cloud when subsequent imagery serves as background. By wise selection of the images, the positive and negative exhaust cloud images had minimal overlap and posed little difficulty for image interpretation.

Quantitative analysis of the IR imagery for the first 1.25 to 4.5 min after launch documented the cloud's rise rate, expansion rate, bearing, and speed without recourse to other data. The "ground cloud" is defined as the lower and more concentrated portion of the rocket's exhaust cloud that can diffuse to the ground. The "launch column" or contrail is defined as the trail of the rapidly moving rocket that extends above the more spherical "ground cloud."

The T-0.7 h rawinsonde pre-launch meteorology data are documented in Appendix B and referenced in this section. Those rawinsonde wind data were used to run the "normal launch" REEDM predictions. The complete output for the T-0.7 h REEDM predictions is documented in Appendix A and referenced in this section.

2.3 Field Deployment

2.3.1 Planning

The Aerospace Corporation's participants are listed in various teams below (members of the imaging teams for A-18 are indicated with asterisks):

Technology Operations
  Space and Environment Technology Center
    Surveillance Technology Department (STD)
      J. T. Knudtson, Director of STD
      K. L. Foster* and B. A. Rockie* (Bldg 900 Site)
      D. K. Stone* and J. T. Valero* (MOTU Site)
      B. P. Kasper* (STF Site)
      R. S. Precious, Secretary of STD

Space Launch Operations
  Systems Engineering Directorate
    Environmental Systems
      N. F. Dowling, Systems Director
      H. L. Lundblad, MVP Manager
  Western Range
    Systems Engineering Directorate
      Virginia Hood, Security

Brian P. Kasper acted as the Field Crew Team Leader for this mission. K. L. Foster reviewed the imagery and documented the calibration information required for PLMTRACK. R. N. Abernathy analyzed the imagery using PLMTRACK, PLMVOL, and Excel.

2.3.2 Equipment

The equipment at each site included all the hardware and software necessary to record and document the launch, to communicate between sites, and to supply backup power in case of an outage at the fixed power distribution points. The VIRIS consists of an array of three full and one back-up (excluding the IR imager) cloud tracking systems and was designed and fabricated at the request of Space Launch Operations, Systems Engineering Directorate, at The Aerospace Corporation. Each full tracking system consists of coaligned visible and IR (8–12 μm) imagers, mounted on an azimuth- and elevation-encoding tripod, with an associated data acquisition and display console. The combination of visible and IR imagers permits cloud tracking in both daylight and darkness. The unique capabilities built into the VCR hardware include digital insertion of imager azimuth (AZ), elevation (EL), time, and GPS location. The system electronics is integrated in a single package, which has been ruggedized for field use. Pre-wiring of this package makes deployment of these imager systems straightforward, usually requiring less than 45 min for instrumentation at a site to become fully operational.

For the Titan IVB A-18 mission, the operators at each site set the FOV of the visible imager using the adjustable 10 to 110 mm electronic zoom lens. They also selected the best lens for the IR

imager. All operators rotated the tripod head to keep the ground cloud within the FOV as it moved from the launch pad. Table 1 documents the FOV used by the IR imager at each of the sites.

All three imaging systems deployed for the Titan IVB A-18 mission were capable of total autonomy. Each VIRIS has an on-board differential-ready Xybion GPS receiver that can be used to document each imager's position with moderate spatial resolution. Typically, 35 m is the precision in the horizontal plane and 100 m is the precision in the vertical plane. For the A-18 imagery sites, a Trimble GPS with Marine differential correction provided more accurate GPS data (2 m horizontal and 7 m vertical resolution) for each of the surveyed camera sites. Gasoline-powered AC generators (Honda Ex1000) are insurance against loss or absence of facility power. The Stirling cooler option for the AGEMA 900 series IR imager was chosen so that liquid nitrogen would not be required at the sites. Each unit is transportable in a standard utility wagon (e.g., Ford Explorer).

The AZ/EL angle encoder for all imager systems was calibrated using reference objects (e.g., SLC-4E) within the field of view of the imager. When reference objects are not part of the geodetic survey database, the GPS location uncertainty is the dominant term in the positional accuracy. Imager pixelation and operator error in edge detection contribute as well to the error in defining the cloud boundary. The 0.07° step size in the tripod angle encoders is a third source of error. The analysis accuracy is determined either by the availability of optimal references for AZ/EL calibration or by the step size for the tripod angle encoder. Typically the VIRIS system provides 0.1° accuracy in both elevation and azimuth.

Table 1. Field of View (FOV) for Imagery Sites during A-18 Mission

Imagery Site	Imager Type (Visible or IR)	FOV(horizontal) (degrees)	FOV(vertical) (degrees)
Spin Test Facility	AGEMA Infrared	41.02	20.75
Building 900	AGEMA Infrared	technical difficulties	technical difficulties
MOTU	AGEMA Infrared	40.42	20.26

2.4 Processing of Imagery Data

The processing of the imagery data requires several transformations that are performed upon return to The Aerospace Corporation:

1. Digitizing frames of the visible imagery (i.e., daylight launches).
2. Measuring the pixel locations of the reference sites within each image (i.e., FOV and angular calibration).
3. Measuring the pixel locations of cloud features in digitized images.
4. Converting pixel locations to azimuth and elevation readings.
5. Calculating cloud characteristics (i.e., position in Cartesian coordinates relative to the launch pad).

The processing requires the use of specialized hardware and software. When used, visible images of the cloud are digitized at precise times, beginning with time intervals of 15 s, then 30 s, then 1 min as the cloud evolves. The AGEMA 900 IR imagers produce digital images every 15 s in the field. A set of digitized images is selected for specific times following the launch and from each of the available imagery sites. Time, AZ, and EL are tabulated for each set. A setup file is created for each of these sets, containing all relevant information necessary to compute the cloud geometry using the imagery. The Aerospace Corporation's programs, **PLMTRACK** and **PLMVOL,** are run to digitize the x, y, and z coordinates of cloud features and to estimate the volume of the exhaust cloud, respectively. These programs report the x and y coordinates relative to the launch pad and the z coordinate as height above MSL. We converted the height MSL to height above ground level (AGL) by subtracting the 519 m MSL for the height of SLC-4E. This allows direct comparison of the imagery-derived data to REEDM's output.

PLMTRACK is a software program developed and maintained in the Surveillance Technology Department (STD) of The Aerospace Corporation by Brian P. Kasper. It is designed to analyze pairs of cloud images synchronized in time. In various versions,[1] **PLMTRACK** has used the linear and rigorous (i.e., trigonometric) methods of interpreting pixels as AZ and EL and vice versa. **PLMTRACK** provides an absolute method of triangulating the position of the ground cloud without making any assumptions regarding the position of the ground cloud. This report presents the rigorous trigonometric **PLMTRACK** results.

When using the **PLMTRACK Line Method**, the operator selects the location of a particular cloud feature in the images from the two imager sites by moving a screen pointer to the desired feature in each image and clicking a mouse button. **PLMTRACK** then calculates the point of nearest approach to the two rays defined by the selected points. The three-dimensional location of this feature is then written to a data file.

Another implementation of **PLMTRACK** is illustrated in Figure 1. When using the **PLMTRACK Box Method**, the operator draws a rectangle about a cloud feature in the images from the two imager sites by moving a screen pointer to the extreme corners of the rectangles and clicking a mouse button. **PLMTRACK** then calculates the closest approach for various rays as illustrated in Figure 1 and described below. The top of the cloud is defined by rays determining T1 and T2 (i.e., T1 x T2); the bottom is determined by rays defining B1 and B2 (i.e., B1 x B2); and the middle is defined by the geometric mean of top and bottom (i.e., M1 x M2). To define the "faces" of the "box," the points of closest approach for ray M1 with L2 and R2 (the left and right tangents to the cloud from Imager 2) are defined (i.e., M1 x L2 and M1 x R2). A similar procedure is used to define the points of closest approach for M2 with L1 and R1, yielding M2 x R1 and M2 x L1. In addition to the centers of the faces of the "box," the intersects of the left and right rays document the four vertices for the XY polygon. Thus, eleven points are defined for the six faced "box" surrounding the cloud (a point in the center of each of the six faces, four vertices for the XY polygon, plus a middle point for the "box"). These eleven sets of x, y, and z coordinates are written to a file.

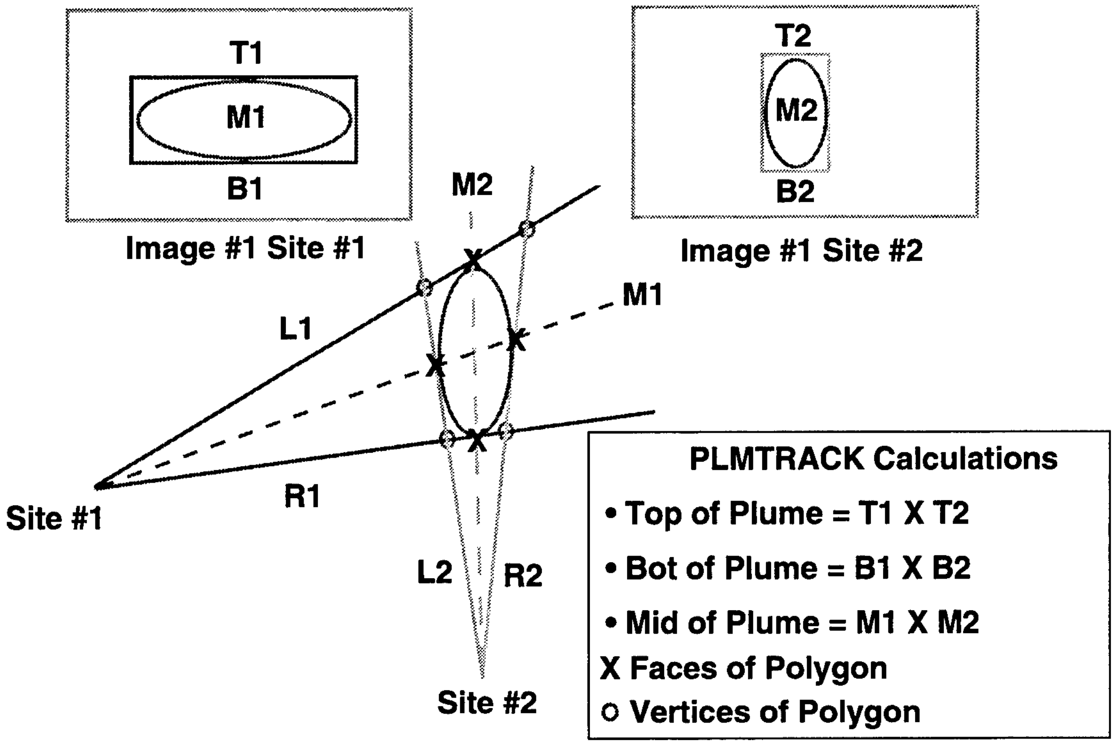


Figure 1. Implementation of the PLMTRACK "box" method with two imagers.

When two imagers are viewing the cloud simultaneously, a four-sided polygon method (documented in Figure 2) has been employed as a way to document the maximum extent of the cloud (i.e., a ground-plane projection) for each set of images. With three imagers, there would be a triply redundant determination of the top, middle, and bottom of the cloud by **PLMTRACK**. The horizontal extent of the cloud is determined by defining the rays from each imager that are tangential to the widest part of the cloud as seen from that site. Projection of these extreme rays for each imager on the x-y ground plane forms a polygon that bounds all material in the cloud at all altitudes, as shown in Figure 2. Thus, when an aircraft is flown against the ground cloud (i.e., K-15, K-16, K-22, and K-23 missions), one expects to see aircraft HCl sampling "hits" fall within this polygon, regardless of the sampling altitude. When the polygon area is combined with the mean cloud height (i.e., the difference between the top and the bottom of the cloud), one can obtain an upper bound for cloud volume. As illustrated in Figure 2 (a ground projection of the cloud's extent), the shaded area within the polygon documents a possible cloud shape that is consistent with the polygon.

The utility of the polygon method has been documented in a previous report[2] for the K-23 mission. In that report, the polygons from imagery were correlated with aircraft HCl measurements of cloud dimensions and average HCl concentrations for the Titan IVA K-23 launch cloud. After correcting for Geomet time response, the K-23 dataset established that HCl concentrations detectable by an aircraft-based Geomet total HCl detector were mostly contained by the six-sided polygon areas for the first 20 min after launch. The K-23 data established that the imagery-derived position of the visible cloud correlates with the measurable HCl concentrations. A similar treatment is possible with the A-18 imagery (without aircraft data) and allows a mapping of the growth and position of the cloud over time.

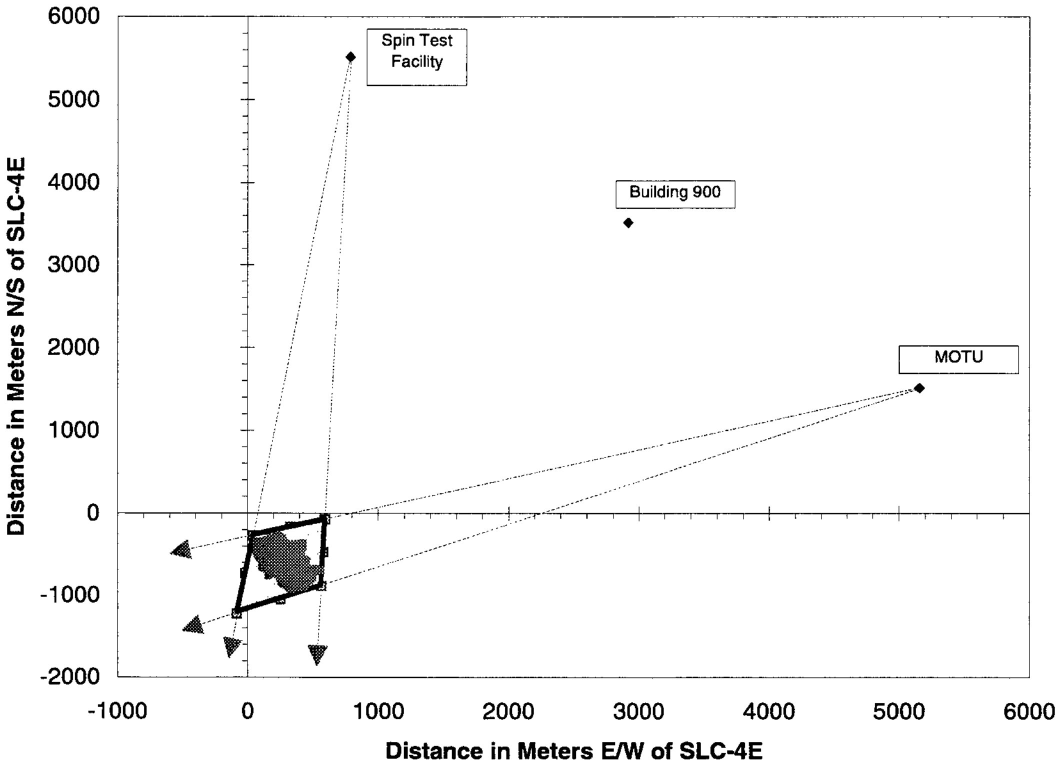


Figure 2. A-18 cloud extent derived from the PLMTRACK polygon analysis. The imager positions and rays are actual A-18 data for T+01:15 (mm:ss) after launch. The irregular shape within the polygon is a cartoon illustrating a possible cloud geometry consistent with the polygon and is included for heuristic purposes.

Brian P. Kasper also created and maintains the **PLMVOL** program at The Aerospace Corporation. **PLMVOL** provides a convenient way of triangulating all of the volume elements that could be occupied by an object using imagery from two (or more) sites. Like **PLMTRACK, PLMVOL** has used the linear and rigorous (i.e., trigonometric) methods of interpreting pixels as AZ and EL and vice versa. For the A-18 mission, the rigorous trigonometric **PLMVOL** algorithm provided an absolute method of triangulating the position and volume of the ground cloud. The analyst outlined the edge of the ground cloud in simultaneously acquired images from the two sites. **PLMVOL** determined all of the pixels that were within the outlines in each image and projected the rays for all of those pixels into space. **PLMVOL** defined volume elements in space and determined which volume elements were intercepted by the projected rays from all imagery sites. These intersected volume elements could be occupied by the ground cloud. **PLMVOL** reports the x,y,z coordinates for all "occupied" volume elements. The coordinates are relative to a reference (i.e., SLC-4E for x and y and mean sea level for z). **PLMVOL** calculates the total volume (i.e., sum of all occupied volume elements), the sphere-equivalent radius, and the mean altitude for the ground cloud (i.e., mean position of all occupied volume elements). For facile comparison to REEDM, this report uses altitude relative to SLC-4E pad (i.e., AGL) rather than MSL in all plots.

The **PLMVOL** approach is illustrated by Figure 3 for simultaneous images of the Titan IV K-23 normal launch cloud from three sites. We used the K-23 images to illustrate **PLMVOL** since that

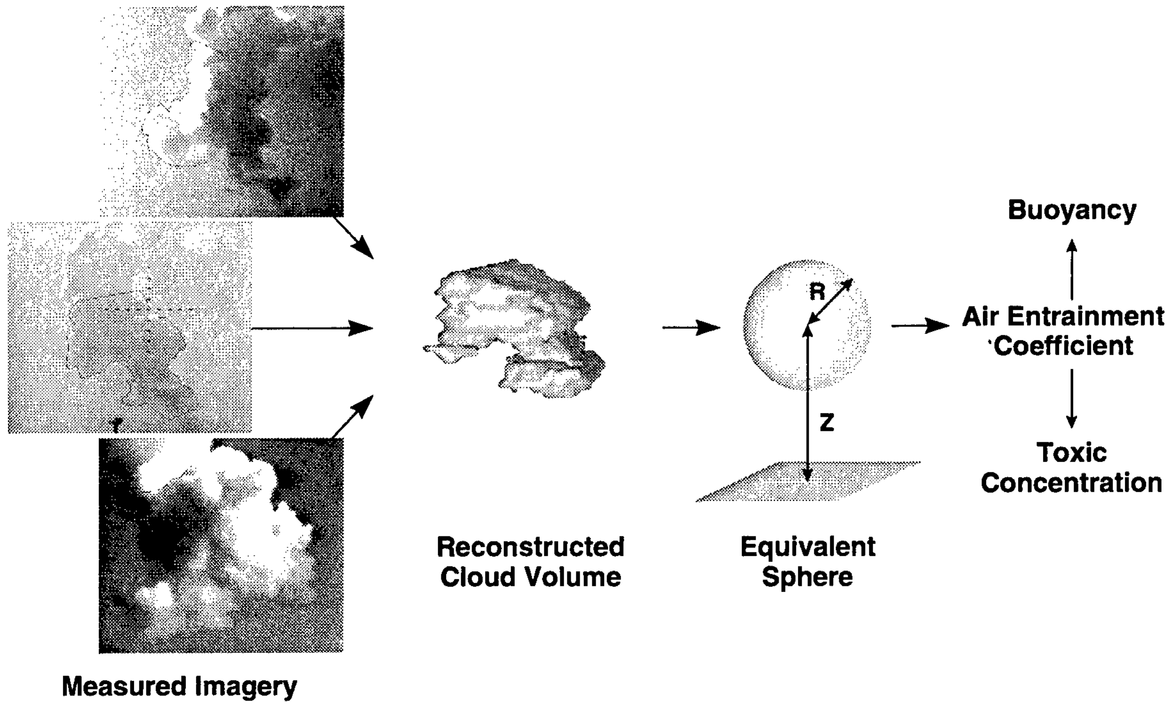


Figure 3. PLMVOL approach illustrated by Titan IV K-23 ground cloud images.

cloud had a more complicated shape, and imagery was available from three sites. The **PLMVOL**-derived reconstructed cloud is shown from a perspective similar to the middle image in Figure 3, but can be viewed from any perspective.

PLMVOL analysis of the A-18 imagery was possible between 0.25 and 4.5 min after the launch. There is excellent agreement between the **PLMVOL** and **PLMTRACK** results. In addition to the ground track, the rise rate, and the extent that are also derived from **PLMTRACK** analysis, **PLMVOL** provided volumetric data and altitude-dependent extent. Even though low-lying atmospheric clouds blocked the view of the top of the cloud by 1.25 min after launch, **PLMVOL** analysis tracked the bottom of the cloud till 4.5 min after launch.

2.5 Results and Discussion

2.5.1. Correlation of Ground Cloud Bearing with Wind Direction

Figure 4 presents the imagery-derived cloud bearing and the T-0.7h REEDM version 7.08 predicted ground cloud bearing as arrows originating from the launch pad and as text. The darkly bordered text box and wide dark arrow are imagery data while the lightly bordered text box and the medium wide arrow are the REEDM prediction. The REEDM predictions resulted from a run using the version 7.08 defaults that are documented in a later section. Figure 4 also documents the rawinsonde wind directions at the REEDM version 7.08 predicted height for the top, middle, and bottom of the stabilized ground cloud. The rawinsonde wind bearings are illustrated with narrow arrows originating from an arbitrary point near the top of the map and in a narrowly bordered text box. The rawinsonde release site was on North VAFB at building 1764 and, therefore, was not on this map of South

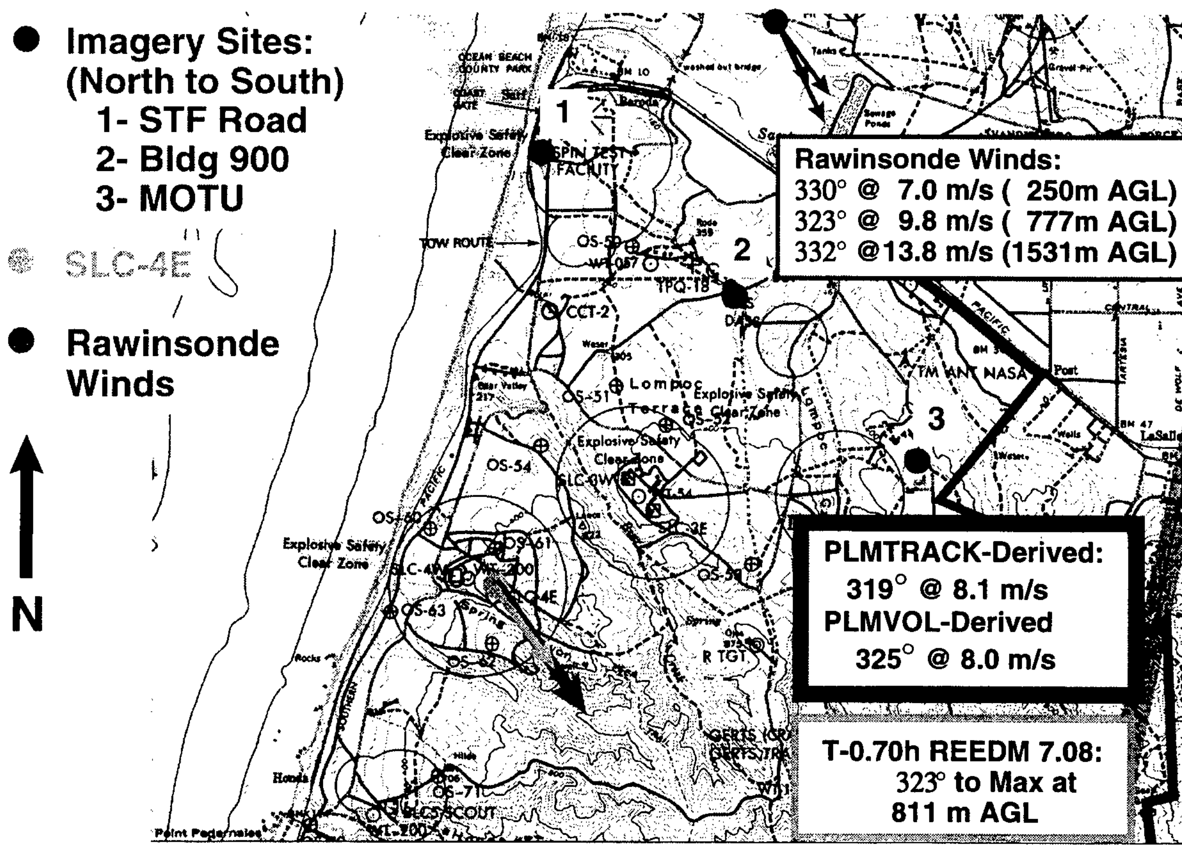


Figure 4. A Map Documenting the Imagery Sites, the A-18 Ground Cloud's Bearing (derived from infrared imagery), the T-0.7h REEDM Prediction for the Ground Cloud's Bearing (at stabilization height), and the 01:52 GMT (T-0.7h) Rawinsonde Wind Directions at the Predicted Cloud Stabilization Heights (Bottom, Middle and Top).

VAFB. Lastly, Figure 4 documents the locations of SLC-4E launch pad and the three imagery sites (Spin Test Facility, Building 900, and MOTU) that were operated by The Aerospace Corporation for the A-18 mission. All directions are reported in rawinsonde convention [defined fully in Subsection 2.5.4]. Briefly, the arrows indicate the direction the cloud would move for a wind coming from the reported angle (clockwise from north).

As illustrated in Figure 4, there is agreement between the imagery-derived cloud bearing, the REEDM version 7.08 predicted cloud bearing, and the rawinsonde wind directions at the equivalent heights. The quantitative imagery documented a cloud bearing of 325° by **PLMVOL** analysis (i.e., wide arrow in Figure 4) and 319° by **PLMTRACK** analysis during the first 1.25 min after launch. REEDM version 7.08 predicted a shift in cloud bearing during rise: 337° at 17 m altitude to 323° at 811 m altitude. REEDM version 7.08 predicted the cloud's bearing as 323° (i.e., medium arrow in Figure 4) to the maximum cloud concentration at the predicted stabilization height (i.e., 811 m AGL). This is almost identical to the predicted cloud bearing of 325° to the maximum cloud concentration at ground level. After stabilization, REEDM predicts a 324° cloud bearing at 811 m AGL (based upon the average wind in the first mixing layer). At ground level, the cloud's predicted bearing was 325° after stabilization. There are negligible differences in the predicted bearings at the

stabilization height and at ground level due to almost negligible shear in wind direction between the stabilization height and the ground. This is consistent with the imagery and with the T-0.7 h rawinsonde data. Figure 4 also presents the rawinsonde-derived wind directions (330°, 323°, and 332°) associated with the rawinsonde sounding heights (250, 777, and 1531 m AGL) nearest the bottom, middle, and top of the stabilized ground cloud, respectively. These wind directions are from the T-0.7 0h rawinsonde data and at the indicated sounding heights that are closest to the REEDM-predicted stabilization heights of 250, 811, and 1531 m AGL for the bottom, middle, and top of the ground cloud, respectively. After 1.25 min, the view of the top of the cloud was obstructed by low-lying atmospheric clouds. Therefore, the imagery could not measure the stabilization height for the cloud. However, the imagery tracked the bottom of the cloud until 4.5 min after launch. The bottom of the cloud stabilized at a height of 197 m AGL by 3.5 min after launch.

Figure 5 includes raw infrared images for T+0s and T+45s as recorded at the STF site. These raw images have the intensity "folded" to only 6 bits and include artifacts due to an acquisition error. In spite of these complications, it is possible to see the ground cloud, the launch column, and the top of the mobile service tower (MST) at SLC-4E in the lower image (i.e., T=45s). We were able to eliminate the artifacts by subtracting the T+0s image from the T+45s image. This background-subtracted image is included as the lower right image in Figure 6. The upper left image in Figure 6 is the background subtracted T+45s imagery from MOTU Site. In Figure 6, the ground cloud is the broader low-altitude portion of the exhaust and is easily distinguishable from the thinner contrail (i.e., launch column) that extends from the top of the ground cloud. Folding of the intensity resulted in sharp black and white contrasts within the ground cloud, within the atmospheric clouds, and at certain elevations depending upon the absolute magnitude of the radiance. As a result of this folding, the ground cloud appears mainly black in the processed MOTU imagery and mainly white in the STF imagery. In either case, it is easy to differentiate the ground cloud from the background. The northern (STF) and eastern (MOTU) perspectives document asymmetry in the cloud's shape with elongation along the north/south axis (i.e., left/right axis from MOTU perspective). This elongation of the ground cloud resulted from ejection of exhaust to the south by the exhaust duct on SLC-4E pad. The upper portion of each image includes the low-lying atmospheric clouds while the lower portion of each image includes any terrain between the camera site and the launch pad. Since the radiance from the terrain was more constant than the radiance from moving atmospheric clouds, the terrain that was evident in the raw imagery (i.e., Figure 5) is almost perfectly canceled by the subtraction used to process the imagery (i.e., Figure 6).

Figures 7 through 9 are exactly the same background-subtracted images shown in Figure 6 with the addition of an outline about the ground cloud (i.e., in Figure 7), **PLMVOL**'s filling of the outline (i.e., in Figure 8), and **PLMVOL**'s reflection from the intersected volume elements (i.e., in Figure 9). It is apparent from review of Figures 6 through 9 that PLMVOL correctly identified the rays within the outline (i.e., filled the outline) and that PLMVOL correctly identified intersected volume elements (i.e., the reflected rays filled the cloud outline). Therefore, these images document a good calibration of the imagery. If the calibration were bad, **PLMVOL**'s "reflected" rays would not fill the cloud outline.

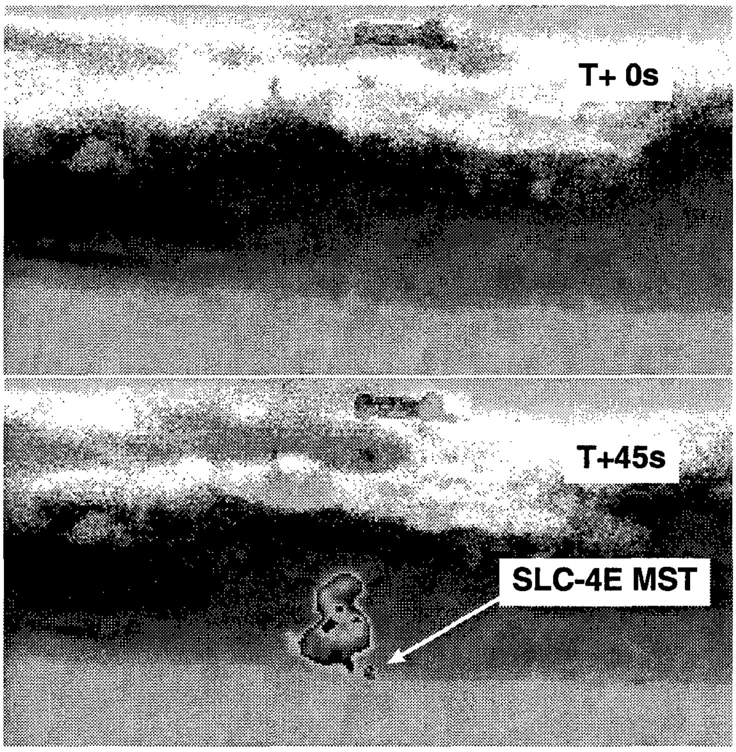


Figure 5. Raw imagery from STF Site at T = 0s (upper) and T = 45s (lower).

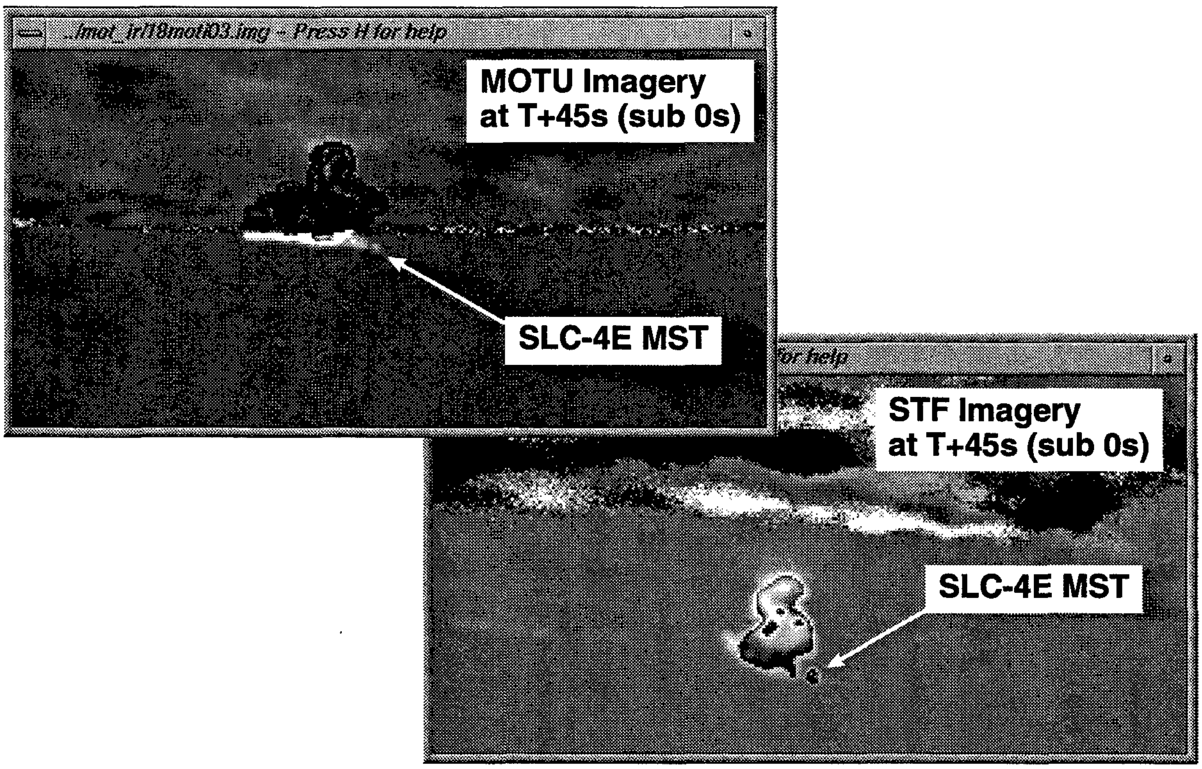


Figure 6. Processed imagery (T = +45s) from MOTU (upper) and STF (lower) Sites.

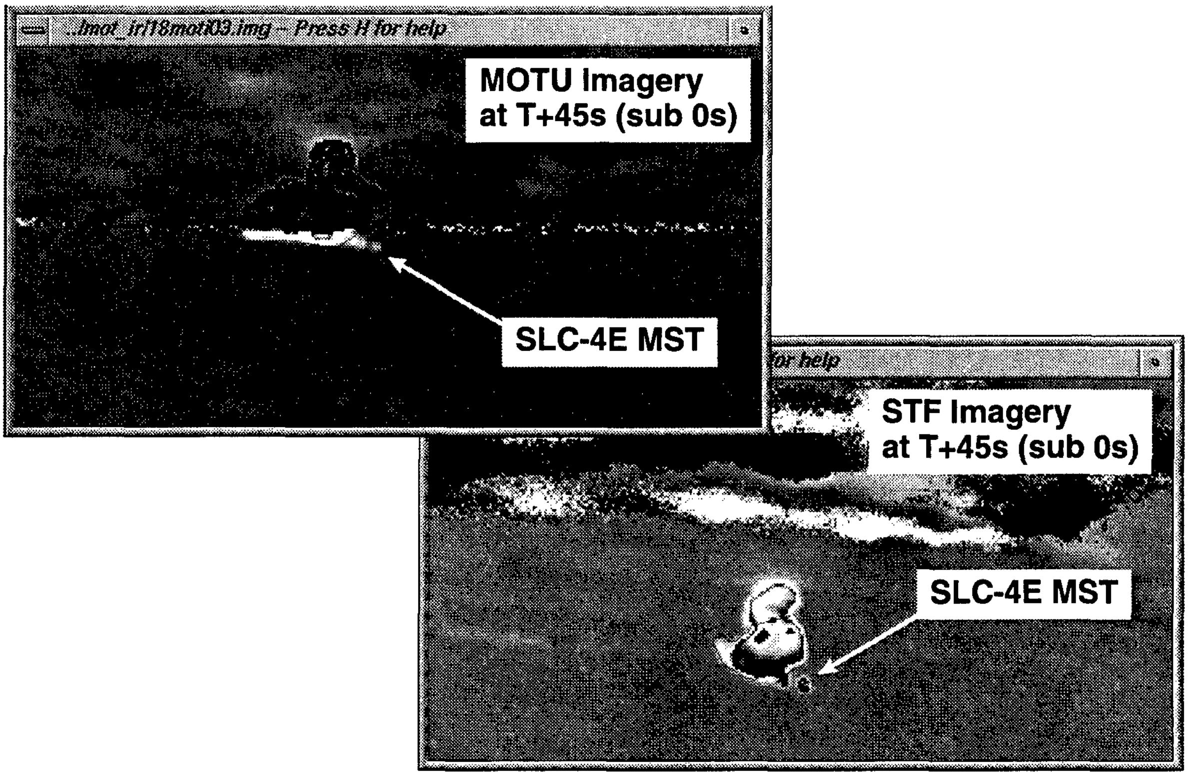


Figure 7. "Outlined" ground cloud (T = +45s) from MOTU (upper) and STF (lower) sites.

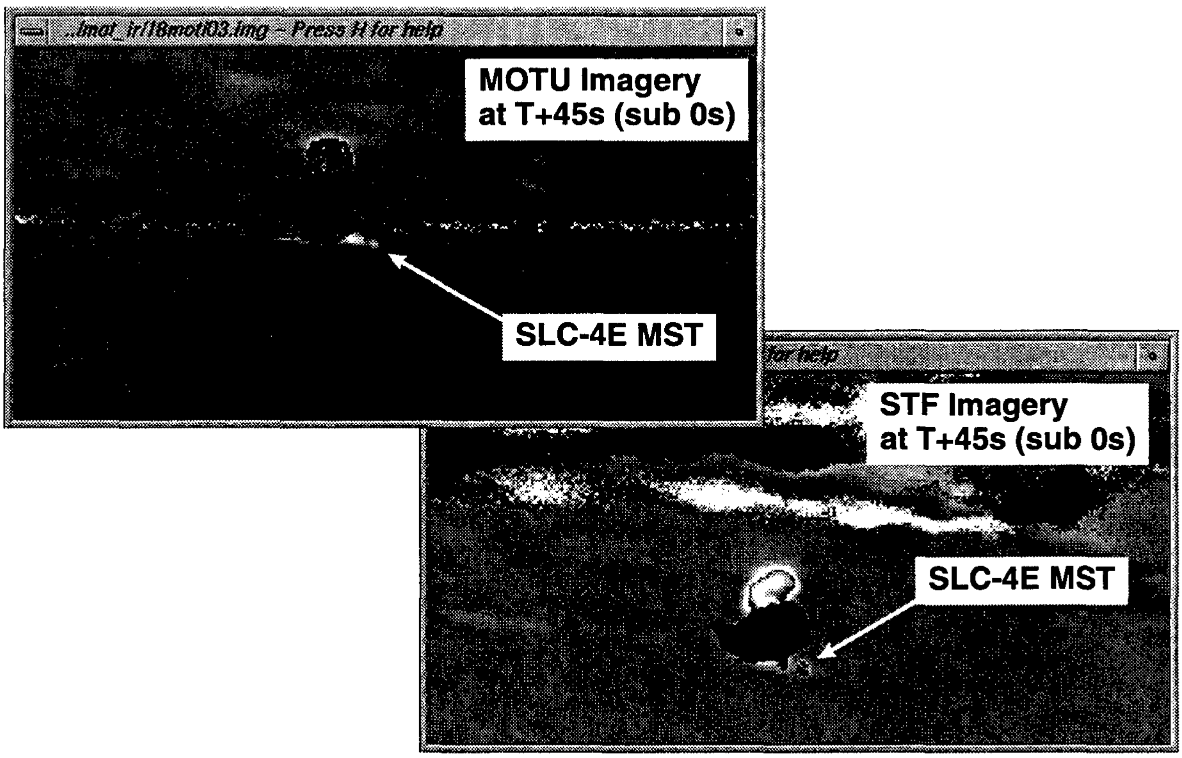


Figure 8. "Filled" ground cloud (T = +45s) from MOTU (upper) and STF (lower) sites.

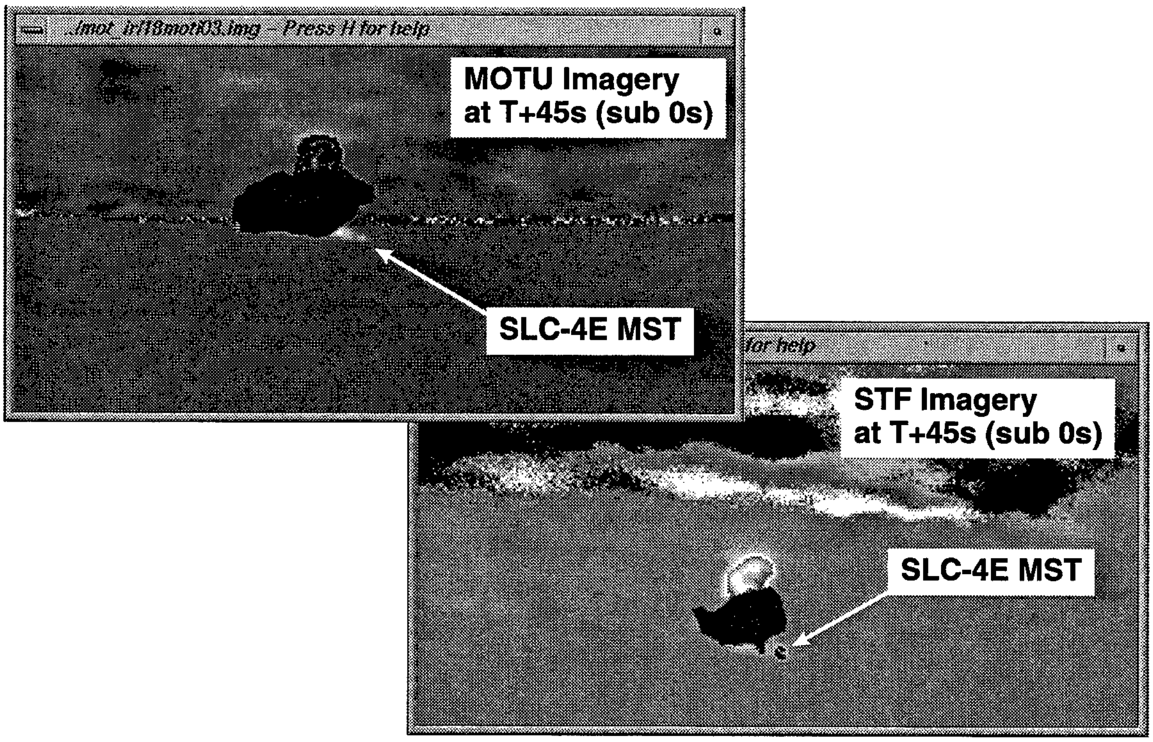
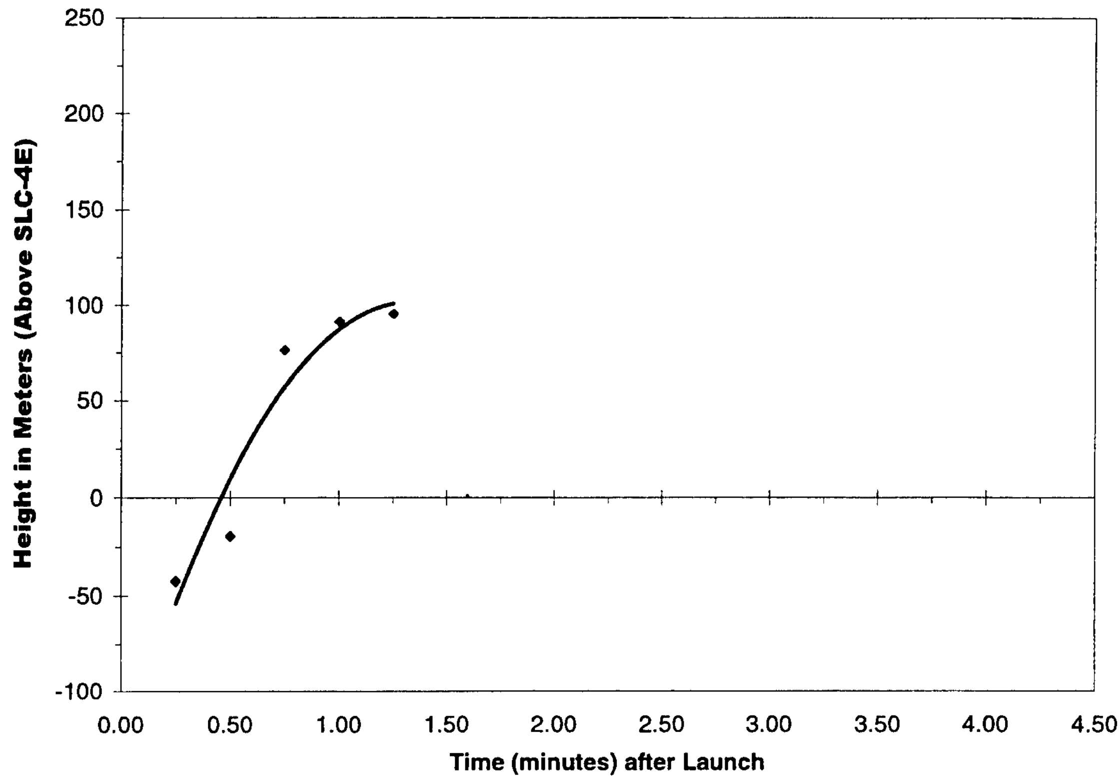


Figure 9. “Reflected” ground cloud (T = +45s) from MOTU (upper) and STF (lower) sites.

2.5.2. Cloud Rise Times and Stabilization Heights

Figures 10 through 12 present the imagery-derived, time-dependent altitude for the “bottom,” the “middle,” and the “top” of the ground cloud based upon **PLMTRACK** analysis (upper plots) and **PLMVOL** analysis (lower plots). In these time plots, all data are plotted as height in meters above SLC-4E (i.e., m Above Ground Level). The analyst used the **PLMTRACK Box Method** for the imagery from the two sites. **PLMTRACK** analysis ended when the top of the cloud was lost into the low-lying atmospheric clouds at times after 1.25 minutes. It is apparent from the linear increase in altitude with time that the cloud had not stabilized by 1.25 min after launch. The analyst also used **PLMVOL** to process the imagery from the two sites. The lower plots in Figures 10 through 12 report the **PLMVOL** results. **PLMVOL** analysis followed the bottom of the cloud (i.e., lower plot in Figure 10) till 4.5 min after launch. The stabilization height for the bottom of the cloud was 197 m (i.e., the average between 3.5 and 4.5 min). The standard deviation was 10 m for these data. The middle (and center) of the cloud had a linear increase in height with time between 0.25 and 1.25 min (i.e., through 350 m AGL). The top of the cloud also had a linear increase in height with time from 0.25 minutes through 1.25 minutes (i.e., through 650 m AGL). Comparison of the upper to lower plots in Figure 10 through Figure 12 reveals excellent agreement between the **PLMTRACK** and **PLMVOL** results.

REEDM version 7.08 (using default input parameters) predicted the following values for the stabilization heights: greater than 250 m AGL for the bottom, 811 m AGL for the middle, and less than 1531 m AGL for the top of the cloud. Therefore, the imagery documented a stabilization height for the bottom of the cloud (i.e., 197±10 m) that was at least 21% lower than the REEDM version 7.08



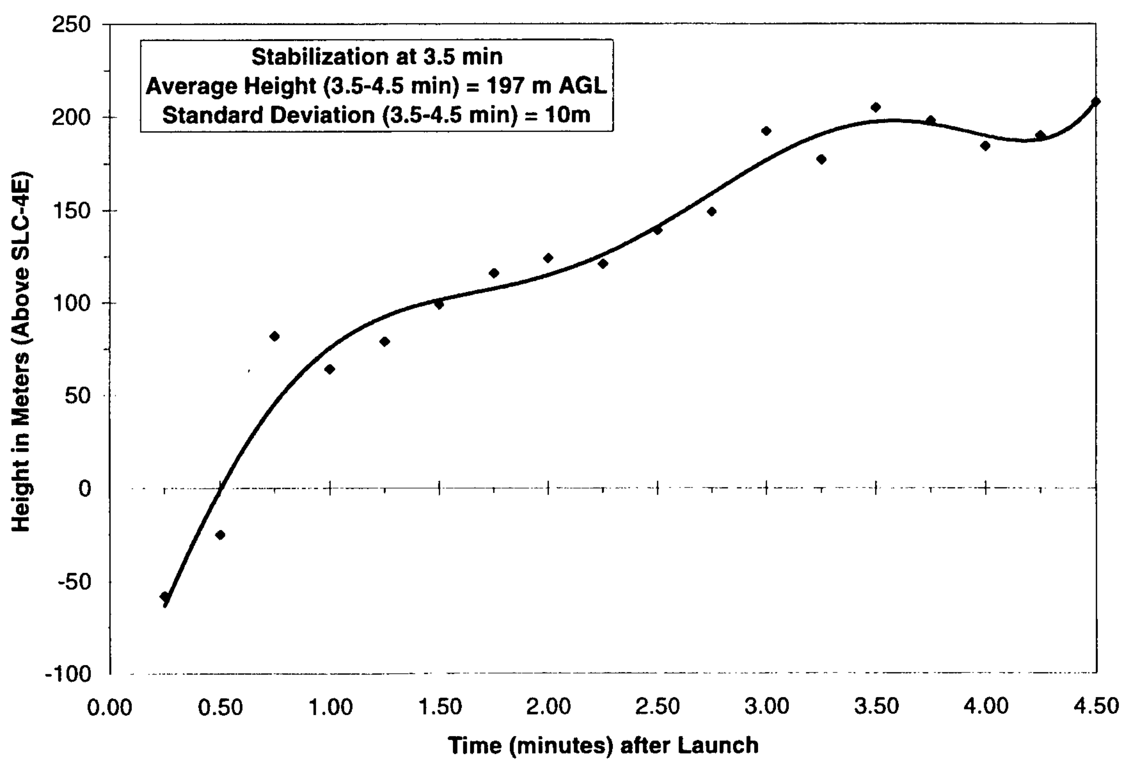


Figure 10. Cloud rise for the bottom of the A-18 cloud (PLMTRACK upper and PLMVOL lower).

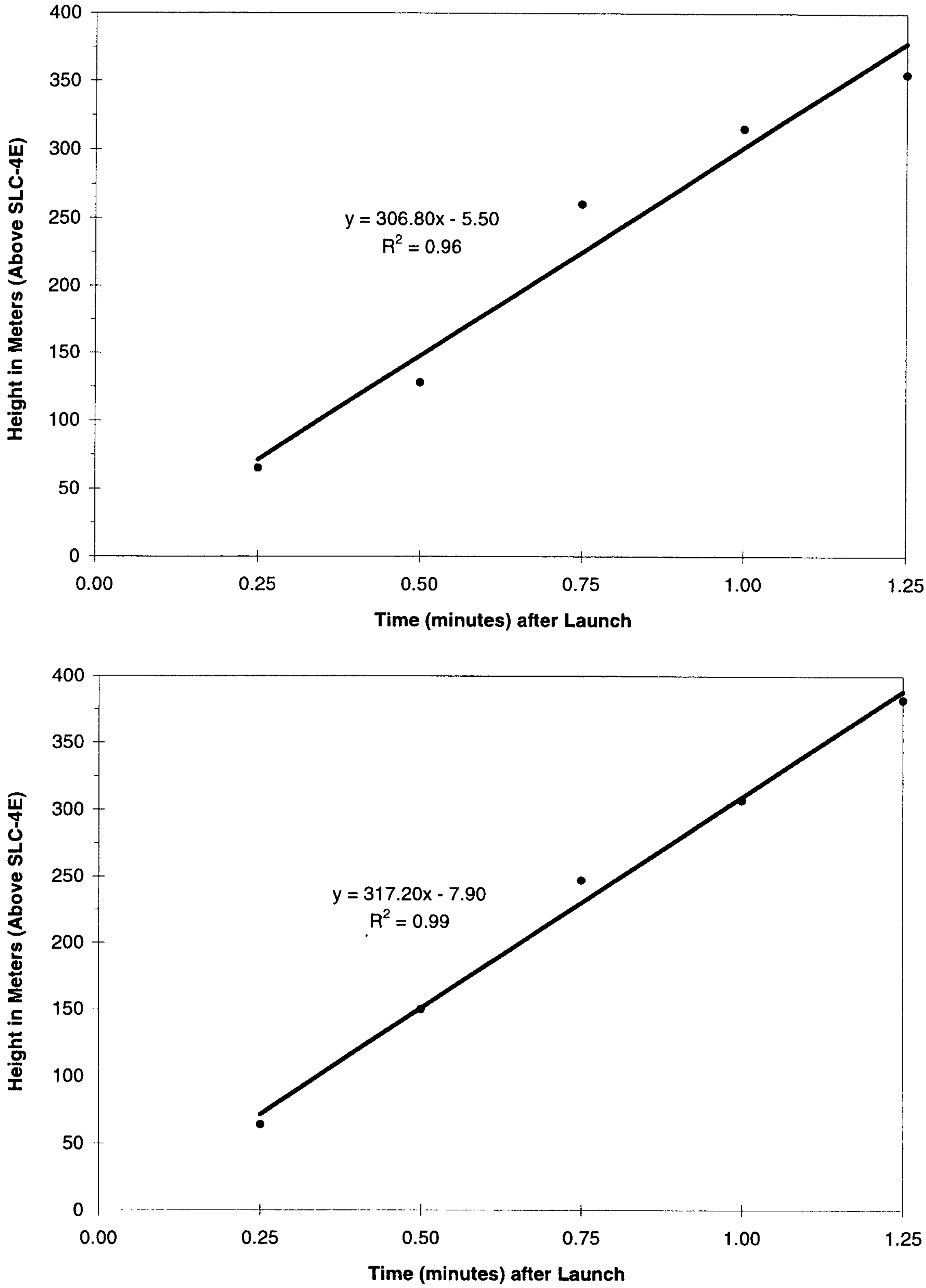


Figure 11. Cloud rise for the middle of the A-18 cloud (PLMTRACK upper and PLMVOL lower).

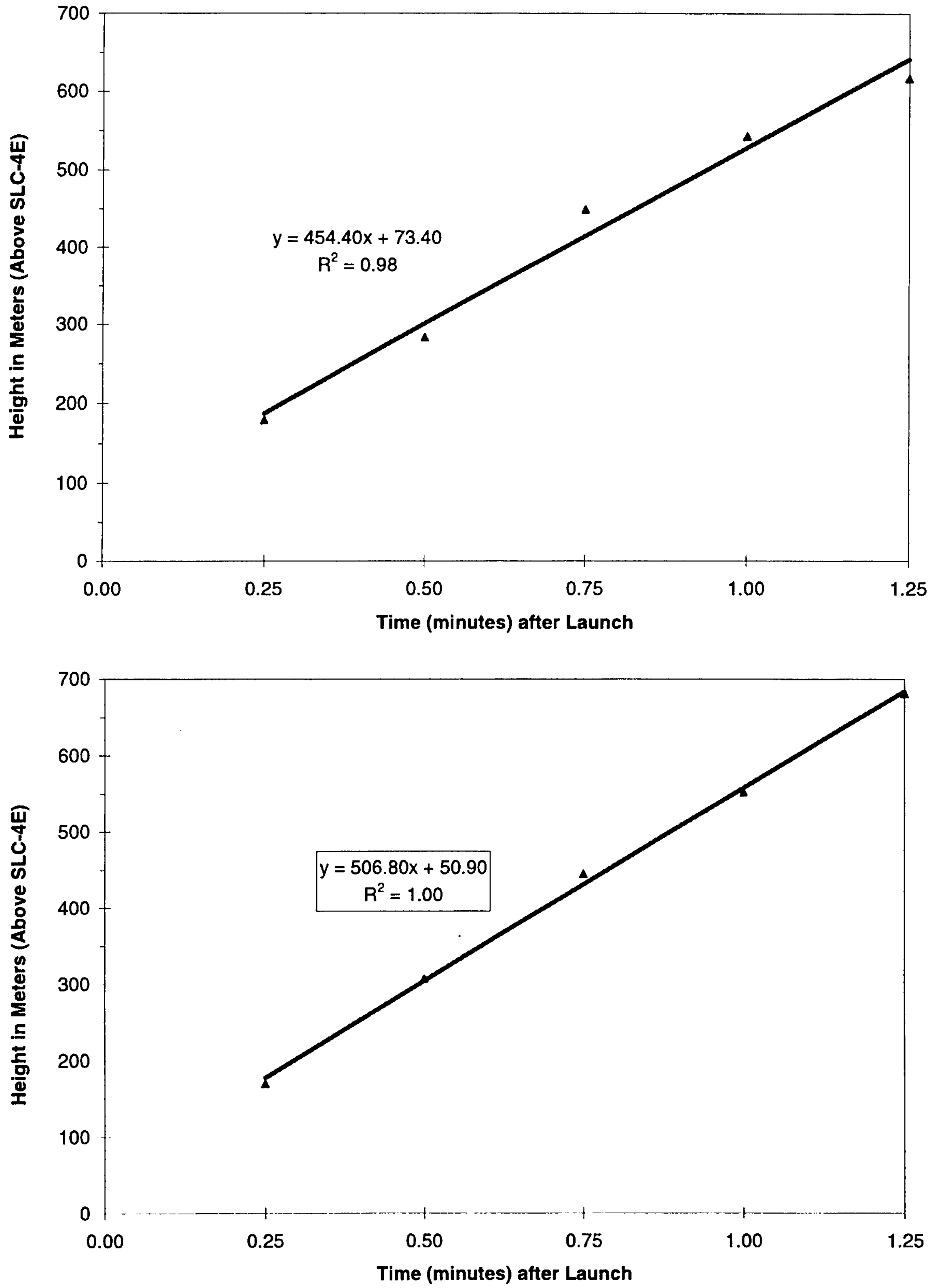


Figure 12. Cloud rise for the top of the A-18 cloud (PLMTRACK upper and PLMVOL lower).

default prediction. The imagery-derived stabilization time was 3.5 min for the bottom of the cloud while REEDM version 7.08 predicted a stabilization time of 3.6 min for the middle of the cloud.

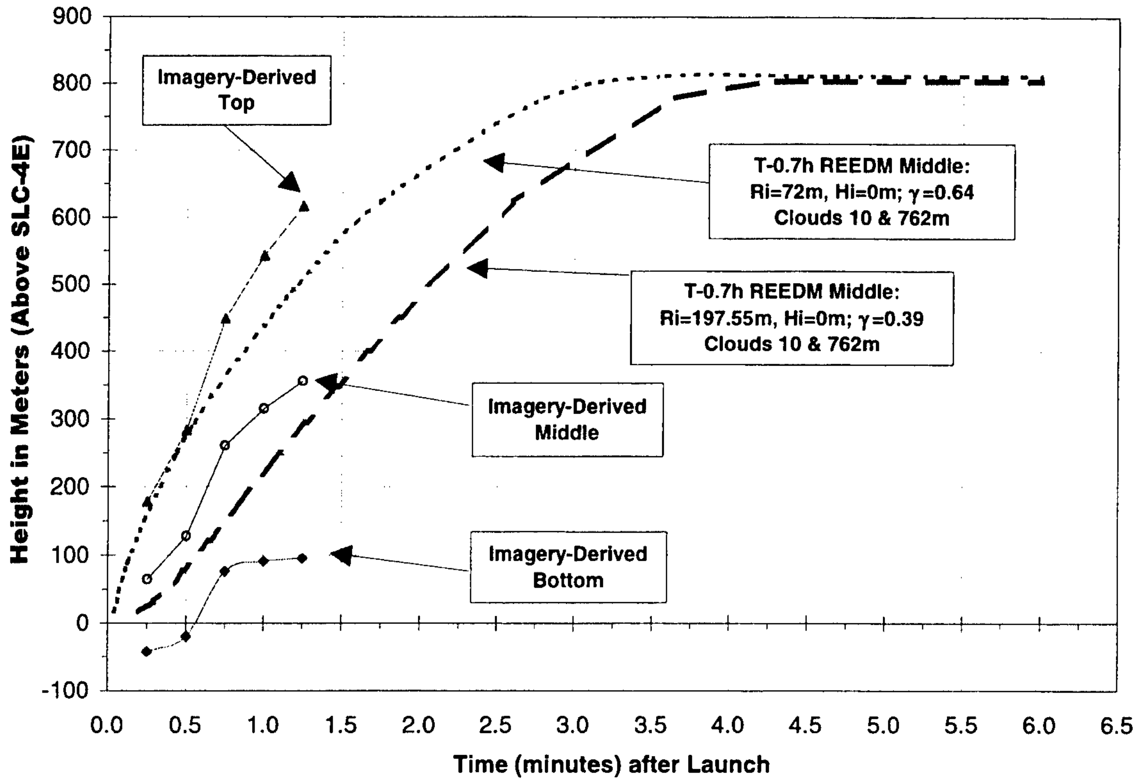
The variances (R^2) of the fits to the data indicate the quality of the fits. A polynomial fit is used when the cloud is tracked through stabilization. A polynomial fit is a convenient method to permit the representation of cloud overshoot and subsequent damped oscillation around the stabilization height. To be consistent with REEDM, stabilization time and height refer to the first maximum in polynomial fits. REEDM predicts that the cloud goes through damped oscillatory motion with a period of $2\pi/S^{1/2}$, where S is the static stability parameter [Ref. 1, Eq. (7)].[3] Sensitivity of REEDM predictions to input parameters has been examined by Womack.[4] Unfortunately, the imagery could not document the stabilization of the A-18 cloud due to low-lying atmospheric clouds.

2.5.3. Comparison of REEDM Prediction to Imagery Data—Rise Rate

Figure 13 presents the **PLMTRACK**-derived (i.e., upper plot) and the **PLMVOL**-derived (i.e., lower plot) heights for the ground cloud's top, middle, and bottom plotted as a function of time following the launch. For comparison, Figure 13 also includes the predicted rise curves for the middle of the cloud from two REEDM version 7.08 runs. Both of these REEDM runs used the T-0.7 h rawinsonde data (Appendix B). Comparison of the upper to the lower plot reveals excellent agreement between the **PLMTRACK** and the **PLMVOL** results. It is apparent that the imagery-derived altitudes for the middle and top of the cloud follow a linear increase with time up to 1.25 min, after which the view of the top of the ground cloud was obstructed by the low-lying atmospheric clouds. In contrast, the default REEDM prediction has significant curvature (i.e., at least a second order function) between 0.5 to 1.25 min. As indicated by the text in Figure 13, the default REEDM run used 72 m as the initial radius, 0 m as the initial height, and 0.64 as the entrainment coefficient. The second "tuned" REEDM run included in Figure 13 used imagery-derived values of 197.55 m for the initial radius, 0 m as the initial height, and 0.39 as the entrainment coefficient. This "tuned" REEDM run exhibits closer agreement with the imagery-derived rise curve for the middle (and center) of the ground cloud. This agreement is illustrated not only by the rate of rise but also by a more linear rise trend.

2.5.4. Comparison of REEDM Prediction to Imagery Data—Bearing and Speed

Figures 14 and 15 document the imagery-derived cloud bearing and speed, respectively. In each figure, the data in the upper plots are derived from **PLMTRACK** analysis while the data in the lower plots are derived from **PLMVOL** analysis. The **PLMTRACK** analysis documents the movement of the "middle" of the cloud while the **PLMVOL** analysis documents the movement of the "center" of the cloud. The "middle" is the average between the top and bottom and between the left and right sides of the **PLMTRACK** boxes. The **PLMVOL** "center" is an average of the locations of all intersected (i.e., "occupied") volume elements reported by **PLMVOL**. In spite of the differences between the two methods, there is excellent agreement between the imagery-derived data presented in the upper and the lower plots.



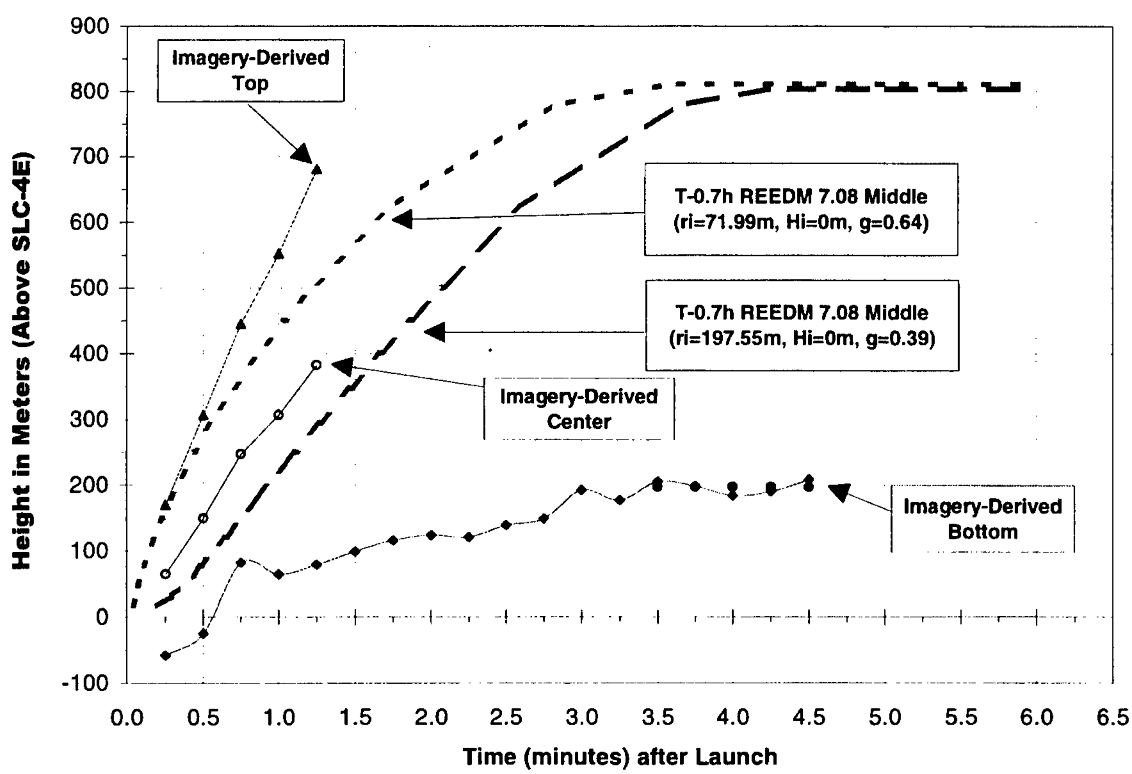


Figure 13. Predicted versus measured rise curves (PLMTRACK upper and PLMVOL lower).

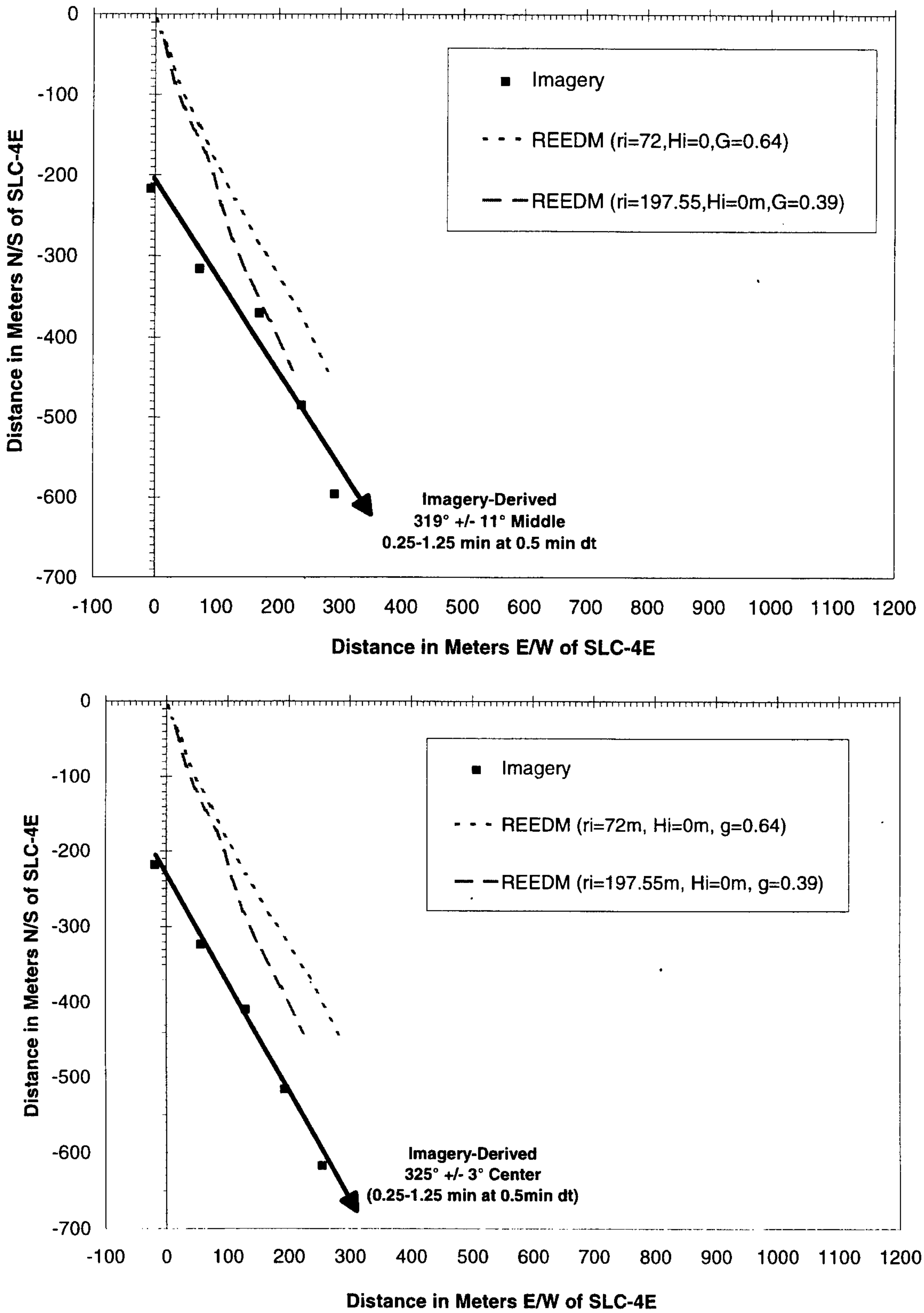
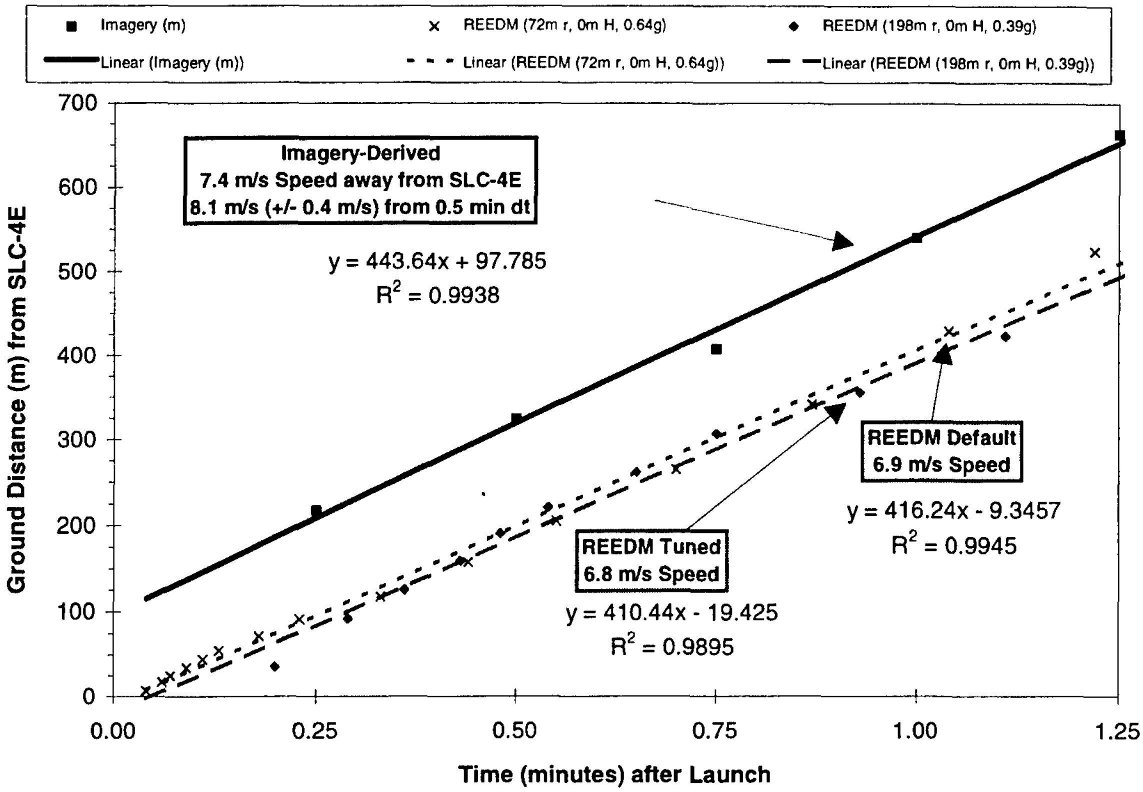


Figure 14. Ground cloud bearing from PLMTRACK (upper) and PLMVOL (lower).



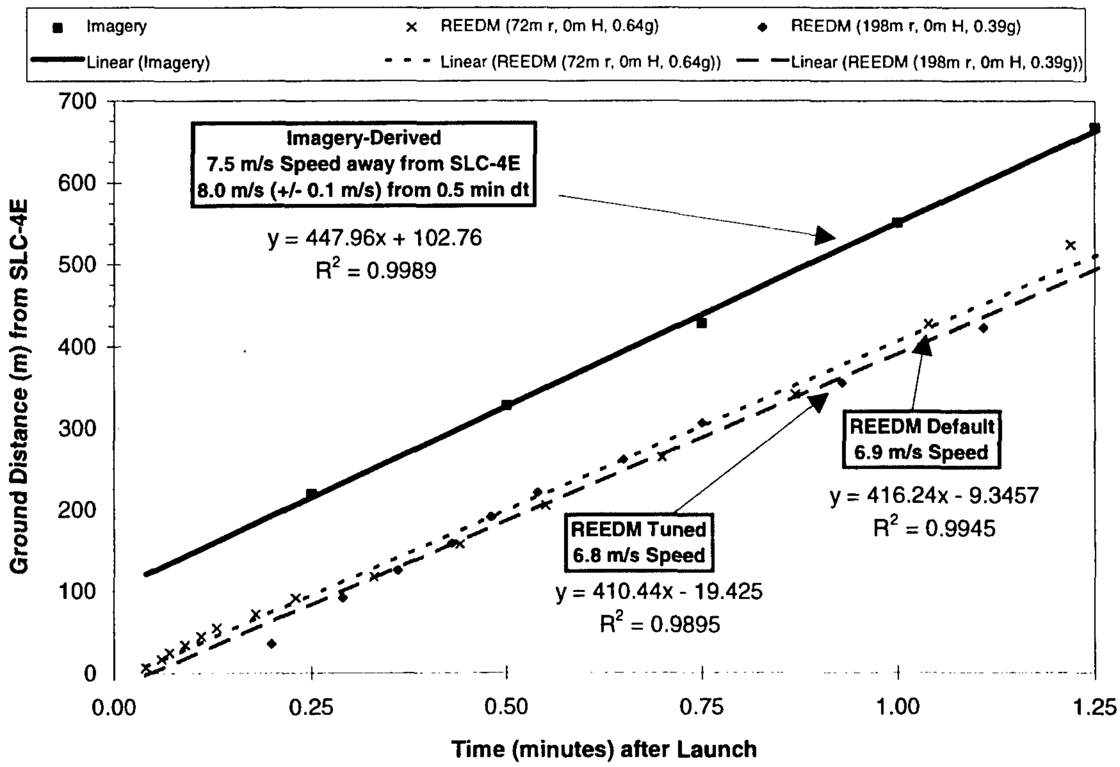


Figure 15. Ground cloud speed from PLMTRACK (upper) and PLMVOL (lower).

In this report, the angles conform to the convention of rawinsonde wind vectors (the angle from which the wind originates that would push the cloud into its imaged position). Thus, the angles are related by

$$J = 180 + F,$$

where ϑ is the equivalent rawinsonde wind angle and Φ is the measured polar angle of the cloud relative to SLC-4E and clockwise of true north. For example, when the cloud is due east of SLC-4E, Φ is 90° and ϑ is 270°.

Figure 14 plots the Cartesian coordinates for the ground cloud between 0.5 and 1.25 min after launch. In the upper plot, the **PLMTRACK**-derived middle of the ground cloud is plotted as distance north/south and distance east/west of SLC-4E. This plot reveals that the cloud's center is displaced to the south of the pad as a result of the exhaust duct geometry at SLC-4E. Between 0.25 and 1.25 min after launch, the cloud had an average bearing of 319° (i.e., south-southeasterly bearing). For comparison, the upper plot in Figure 14 includes two REEDM 7.08 predictions for times between 0 and 1.8 min after launch. These are the same two runs included in Figure 13 and discussed earlier. It is apparent from Figure 14 that REEDM initializes with the middle of the cloud above the pad. Both the default and tuned runs predict a south-southeasterly bearing for the cloud.

The lower plot in Figure 14 documents the **PLMVOL** results for the center of the cloud, which moved along a 325° bearing (i.e., south-southeasterly). The lower plot also includes the predictions from the same two REEDM runs discussed earlier. Again, there is an offset between the prediction and the observation. Apparently, this offset is due to the exhaust duct geometry that ejects the cloud in a southerly direction.

PLMVOL analysis uses a detailed outline about the ground cloud and uses imagery from all available sites simultaneously. **PLMTRACK** analysis uses a rectangle to mark only the broadest extend of the cloud and uses the imagery in a pair-wise fashion. Therefore, the **PLMVOL** results should provide better accuracy than the **PLMTRACK** results. This is consistent with larger scatter in **PLMTRACK**'s "middle" data in the upper plot than in **PLMVOL**'s "center" data in the lower plot. However, this scatter seems to affect the statistics but not the mean for the imagery-derived results (i.e., position, direction, and speed).

Figure 15 documents the speed for the ground cloud by plotting its range from SLC-4E against time for the 1.25 min of available imagery. The **PLMTRACK** results are in the upper plot while the **PLMVOL** results are in the lower plot. In addition to the imagery-derived range, these figures also include the ranges predicted from the two REEDM runs discussed previously and included in Figures 13 and 14. Figure 15 includes the formulae for linear regressive fits to the range versus time data not only for the imagery-derived data but also for the two REEDM predictions. The slopes of these fits were converted to speeds (i.e., reported in text boxes in Figure 15). For the imagery-derived data, a second method provided a mean and standard deviation for the 0.5 min differential speed. These results are also reported in the text boxes. The second method calculated the differential speed from the position data separated by 0.5-min intervals. Comparison of the upper to lower plots reveals excellent agreement between the **PLMTRACK** results and the **PLMVOL** results. However, the two

methods of calculating the cloud's speed from these data result in different values for the cloud's speed. The fit to all five imagery-derived points (i.e., range versus time data) results in a cloud speed away from SLC-4E of 7.4 and 7.5 m/s by **PLMTRACK** and **PLMVOL**, respectively. In contrast, the 0.5-min differential method results in a cloud speed along the clouds bearing of 8.1 (±0.4 standard deviation) and 8.0 m/s (±0.1 standard deviation) by **PLMTRACK** and **PLMVOL**, respectively. As mentioned previously, the **PLMVOL** analysis should provide a better value and, indeed, has a smaller standard deviation. The difference between the two methods is a result of two factors: (1) the offset of the cloud from the pad and (2) its failure to move directly away from the pad. Therefore, the 0.5-min differential speed is, indeed, the along-wind cloud bearing while the slope of the range versus time data is the apparent speed away from SLC-4E. The slope method is appropriate for the REEDM predictions since they originate at the pad. We included both methods of analysis to document the bias associated with the source term (i.e., offset from the launch pad). For predicting far-field effects, one would use the larger 0.5-min differential speed since the offset would become negligible as one moves away from the pad.

Figure 16 documents **PLMVOL** results as an increase in cloud volume with time. Figure 17 conveys the same **PLMVOL** results as an increase in the cloud's sphere-equivalent radius with altitude. The sphere-equivalent radius is the radius of a sphere that has the same volume as measured by **PLMVOL**. The slope of a fit to sphere-equivalent radius plotted against altitude is, by definition, the entrainment coefficient used by REEDM. Therefore, Figure 17 documents a measured entrainment coefficient of 0.39. This is comparable to the imagery-derived entrainment coefficients for the

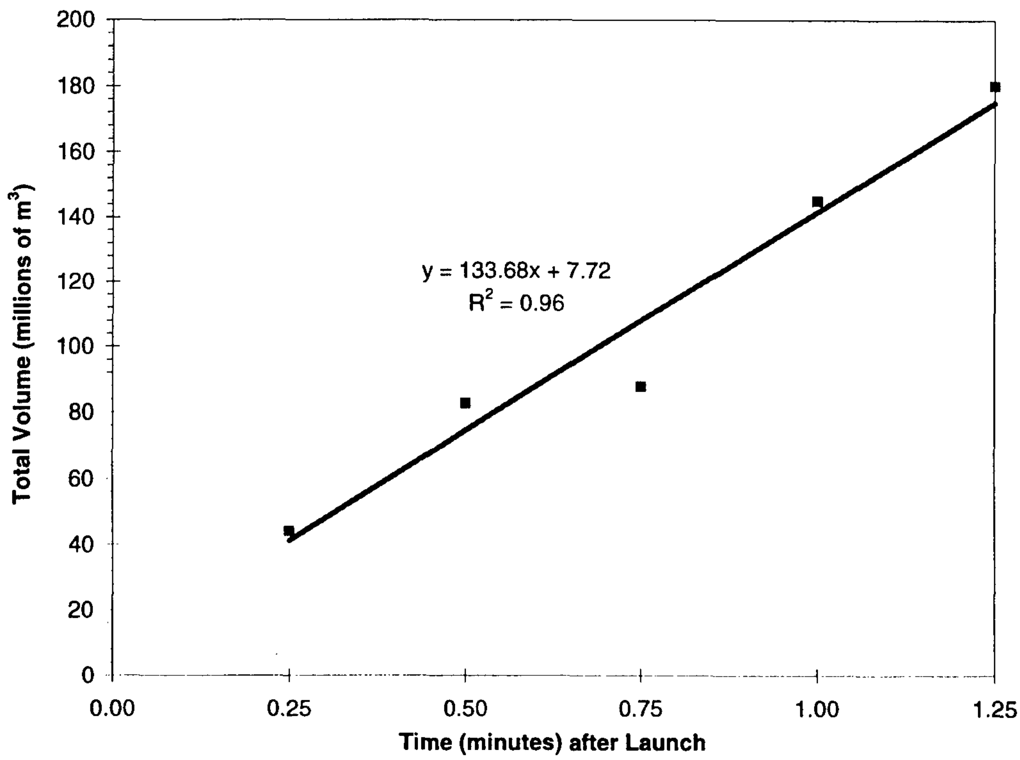


Figure 16. Cloud volume versus time (PLMTRACK upper and PLMVOL lower).

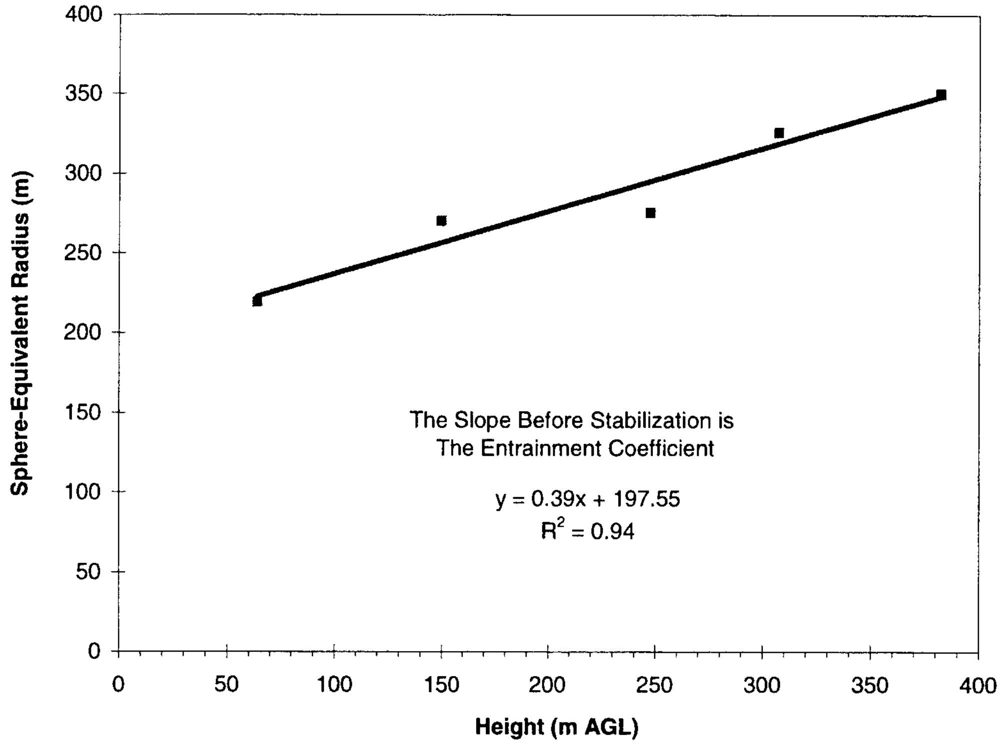


Figure 17. Sphere-equivalent radius versus altitude (PLMTRACK upper and PLMVOL lower).

34D-9 abort cloud (i.e., 0.35), for two Titan IVA launches (i.e., 0.35 for K23 and 0.37 for K19), and for the first Titan IVB launch (i.e., 0.35 for B24). All of the imagery-derived values are substantially smaller than REEDM's default value of 0.64. The intercept of the fit (198m AGL) is the initial cloud radius and is also an input parameter for REEDM. REEDM version 7.08's default value is 72 m AGL for the initial cloud radius.

2.5.5. Comparison of REEDM Prediction to Imagery Data—Summary Table

Table 2 summarizes the imagery derived, the T-0.7 h rawinsonde-measured, and the T-0.7 h REEDM-predicted data for the A-18 ground cloud. Several conclusions can be derived from review of the contents of this table and from the previous discussions.

- There is no imagery-derived stabilization height for the middle of the ground cloud due to the low-lying atmospheric clouds that obscured the top of the cloud after 1.25 minutes.
- The imagery-derived stabilization height (197 m AGL) for the bottom of the cloud is 21% lower than the predicted stabilization height of 250 m AGL.
- The imagery-derived bearing (325° by **PLMVOL**) is in fair agreement both with the T-0.7 h rawinsonde wind (323°) and with the T-0.7 h REEDM Version 7.08 prediction (323°).

- The imagery-derived cloud speed (8.0 m/s) is 16% faster than the T-0.7 h REEDM version 7.08 prediction (6.9 m/s during rise).
- The imagery-derived entrainment coefficient (0.39) is 39% smaller than REEDM's default value (0.64).
- The imagery-derived extrapolated initial cloud height is 0 m while REEDM's default value is 0 m (72 m has been proposed as the new default);
- The imagery-derived extrapolated initial cloud radius (198 m) is 175% larger than REEDM's default value (72 m).
- The imagery documented a linear increase in height with time for the ground cloud, which is in better agreement with the tuned rather than the default REEDM 7.08 predictions.

As discussed previously and documented in Table 2, we included two REEDM predictions in the plots in Figures 13 through 15. The runs were identical except for the values used for the initial cloud radius, the initial cloud height, and the entrainment coefficient. Both REEDM runs used the T-0.7 h rawinsonde data documented in Appendix B. The default run used 72 m, 0 m, and 0.64 for the

Table 2. Summary of A-18 Ground Cloud Data Derived from Infrared Imagery, T-0.7 h Rawinsonde Sounding Data, and T-0.7 h REEDM Predictions.

Attribute	Feature or Period	Imagery (IR only)	Rawinsonde (T – 0.7 h)	REEDM 7.08 (T – 7 h Default)	REEDM 7.08 (T – 7 h Tuned)
Stabilization Height	Top	>650		1531	1230
Meters Above SLC-4E	Middle	>350		811	804
(SLC-4E = 158 m MSL)	Bottom	197		250	450
Stabilization Time	Top				
Minutes After Launch	Middle			3.6	4.2
	Bottom	3.5			
Cloud Bearing (deg)	Top		332		
(rawinsonde)	Middle	319-325	323	324	323
at Specified Levels	Bottom		330		
Cloud Bearing (deg)	After Stab.			324	323
(rawinsonde)	To Max.			323	324
During Time Interval	During Rise	319-325		337–323	337–325
Cloud Speed (m/s)	Top		13.8		
(along trajectory)	Middle	8.0	9.8	8.9	9.8
at Specified Levels	Bottom		7.0		
Cloud Speed (m/s)	After Stab.			8.9	9.8
(along trajectory)	To Max.				
During Time Interval	During Rise	8.0		6.9	6.8
Entrainment Coeff.	During Rise	0.39		0.64	0.39
Initial Radius (m)	At Height = 0	198		72	198
Initial Height (m)	At t = 0	0		0	0
Rise Rate (time)	During Rise	Linear		2nd Order	Linear

initial radius, the initial height, and the entrainment coefficient. These were the default values in our copy of REEDM 7.08. However, 72 m has been proposed as the default value for the initial height. Using a value of 72 m for the initial height made the comparison to the imagery-derived rise curve even worse than illustrated in Figure 13 for our default run. The "tuned" run used 198 m, 0 m, and 0.39 for the initial radius, the initial height, and the entrainment coefficient. Table 2 documents that these values are the imagery-derived values for the A18 mission.

Both REEDM runs report about the same values for the stabilization height of the middle of the cloud, its bearing, and its speed during rise. However, there are significant differences in the predicted values for the stabilization heights of the top and bottom, for the speed after stabilization, and for the stabilization time. Unfortunately, it was not possible to measure all of these predicted characteristics due to low-level atmospheric clouds that obscured the top of the cloud at times later than 1.25 min after launch. As discussed in this report and documented in Table 2, neither REEDM run is a perfect match to the imagery-derived trends.

2.6 Summary and Conclusions

The Titan IVB A-18 mission was launched successfully from the Western Range (SLC-4E) at 1932 PDT (0232 GMT on 24 October 1997) on 23 October 1997. Personnel from The Aerospace Corporation imaged the ground cloud for 4.5 min after the launch from three camera sites. When combined with the AZ/EL readings and the IRIG-B time data, the quantitative imagery documented the rise, stabilization, growth, speed, and bearing of the ground cloud. The cloud rose at a linear rate with time until the top of the cloud penetrated the low-lying atmospheric clouds at 1.25 min after the launch. The bottom of the cloud was tracked through 4.5 min and stabilized at 197 m AGL by 3.5 min after launch. This quantitative imagery data for the A-18 ground cloud will be useful for tuning current and future dispersion models.

The definition of the A-18 exhaust cloud's geometric features was complicated by its three-dimensional shape (i.e., not spherical). However, the imagery successfully documented this complex shape as the cloud evolved (i.e., asymmetric ejection from the exhaust duct, rapid rise of the hot ground cloud, and penetration into the low-lying atmospheric clouds).

Analysis of the imagery data presented in this report has focused on determining parameters that are directly comparable to REEDM predictions. The imagery-derived cloud bearing was similar to T-0.7 h rawinsonde winds and to T-0.7 h REEDM version 7.08 predictions. However, the imagery documented several differences between the ground cloud and REEDM predictions.

- The imagery-derived stabilization height (197 m AGL) for the bottom of the cloud is 21% lower than predicted (250 m AGL).
- The imagery-derived entrainment coefficient (0.39) is 39% smaller than REEDM's default value (0.64).
- The imagery-derived extrapolated initial cloud radius (198 m) is 175% larger than REEDM's default value (72m).

- The imagery documented a linear increase in height with time for the ground cloud while REEDM 7.08's default prediction has significant curvature during the same period.

- The initial position of the ground cloud is offset to the south of the pad.

The Aerospace Corporation has imaged 14 Titan IVA and 2 Titan IVB launches as part of the Model Validation Program. The available Titan IVA imagery documents that REEDM consistently underestimates the stabilization height of the ground cloud. Such overly conservative REEDM predictions can result in unnecessary launch holds at a considerable cost to the Air Force. REEDM did a much better job with the first Titan IVB launch (i.e., B-24). Unfortunately, it was not possible to image the stabilization of the A-18 ground cloud or the second Titan IVB launch (i.e., B-33). Additional Titan IV A and B exhaust cloud data are needed to validate and to tune current and future dispersion models for both ranges (Vandenberg AFB and CCAS) and for the various meteorological conditions associated with round-the-clock and year-round launch schedules.

3. Ground Monitoring of Exhaust Cloud

An instrument package for detecting the passage of the Titan IVA-18 exhaust cloud was placed at Building 512 on south VAFB four hours prior to launch. Building 512 is located on a ridgeline, just south of Honda Ridge Road. It is approximately 5 km south of SLC-4 on an azimuth of 175° from SLC-4. The package consisted of two instruments for the detection of hydrogen chloride (HCl), and sensors for the detection of carbon dioxide, humidity, and temperature. Also included was a Z180 microcomputer that served as a data logger.

The instrument package was placed at Building 512 based on pre-launch wind predictions. A wind shift prior to launch caused the launch exhaust ground cloud to pass to east of Building 512 on an approximate azimuth of 145° from SLC-4. As a result, the sensors detected no exhaust cloud constituents.

The two HCl instruments chosen for this activity were the Interscan detector and a prototype Army instrument developed at the Aberdeen Proving Ground. The Interscan instrument is an electrochemical detector that responds to Cl^- and has a sealed electrochemical cell with a liquid electrolyte. It is routinely used for monitoring by both the Air Force and NASA. The unit used for this activity was borrowed from Patrick AFB and calibrated by the NASA Toxic Vapor Detection Laboratory at Cape Canaveral AS. Drawbacks of this instrument are: (1) it needs to be calibrated frequently with HCl gas, and (2) the response time is somewhat slow (about 30 s). The Army instrument is also an electrochemical instrument sensitive to Cl^-, but uses a flowing solution to trap HCl in a mist. The response time of this instrument is fast (about 5 s), and the instrument is calibrated using standard solutions of Cl^-, which is much easier and more reliable than using HCl mixtures. It should respond equally well to gaseous and aerosol HCl.

Bruce Weiller and Lawrence Wiedeman of the Mechanics and Materials Technology Center of The Aerospace Corporation performed the integration and operation of the instrument package, and also analyzed and reported the results.

References

1. R. N. Abernathy, "Titan 34D-9 Abort Cloud Measurements — Quantitative Imagery from Two Camera Sites," The Aerospace Corporation Technical Report TR-98(1410)-1, The Aerospace Corporation, El Segundo, CA (20 February 1998).

2. R. N. Abernathy, R. F. Heidner III, B. P. Kasper, and J. T. Knudtson,"Visible and Infrared Imagery of the Launch of the Titan IV K-23 from Cape Canaveral Air Force Station on 14 May 1995," Aerospace Report No. TOR-96(1410)-1, The Aerospace Corporation, El Segundo, CA (15 September 1996).

3. J. R. Bjorklund, "User's Manual for the REEDM Version 7 (Rocket Exhaust Effluent Diffusion Model) Computer Program," Vol. I, TR-90-157-01, AF Systems Command, Patrick AFB, FL (April 1990).

4. J. M. Womack, "Rocket Exhaust Effluent Diffusion Model Sensitivity Study," TOR-95(5448)-3, The Aerospace Corporation, El Segundo, CA (May 1995).

Appendix A—REEDM Version 7.08 Predictions for the A-18 Mission

[The material in this section was contributed by R. N. of the Environmental Monitoring and Technology Department of The Aerospace Corporation's Space and Environment Technology Center]. These REEDM version 7.08 runs used the default values for the initial cloud radius (71.99 m), for the initial cloud height (0 m AGL), and for the entrainment coefficient (0.64) as described in Section 2.

This Appendix includes REEDM version 7.08 runs for impact at both the surface (0 m AGL, 158 m MSL) and stabilization height (i.e., 811 m AGL as predicted by REEDM). We include the plots of the rawinsonde meteorological data, the predicted maximum concentration versus downwind distance, and the predicted concentration isopleths overlayed on a range map. These plots are followed by the detailed REEDM report for that run.

Stabilization Height Predictions

The following figures and table are the REEDM version 7.08 output for the default stabilization height run. These predictions were compared with actual A-18 ground cloud observations in Section 2 for the quantitative imagery.

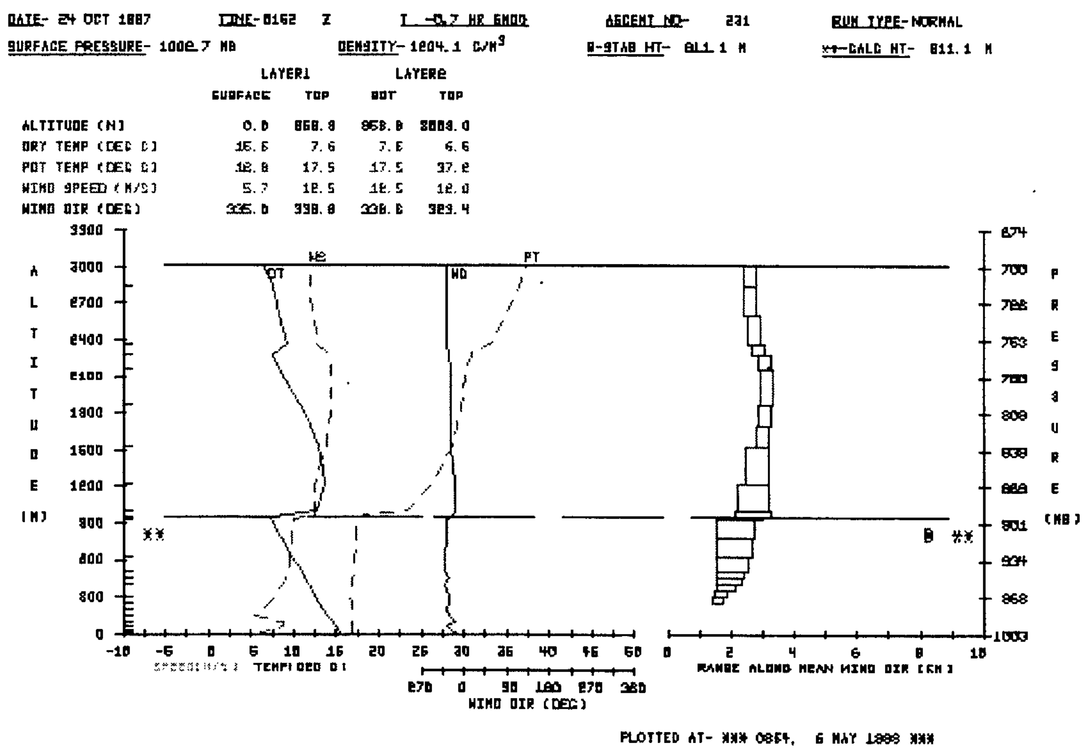


Figure 1A. Meteorological Output Plot from REEDM Version 7.08 for A-18 Mission Using T-0.7h Rawinsonde Data.

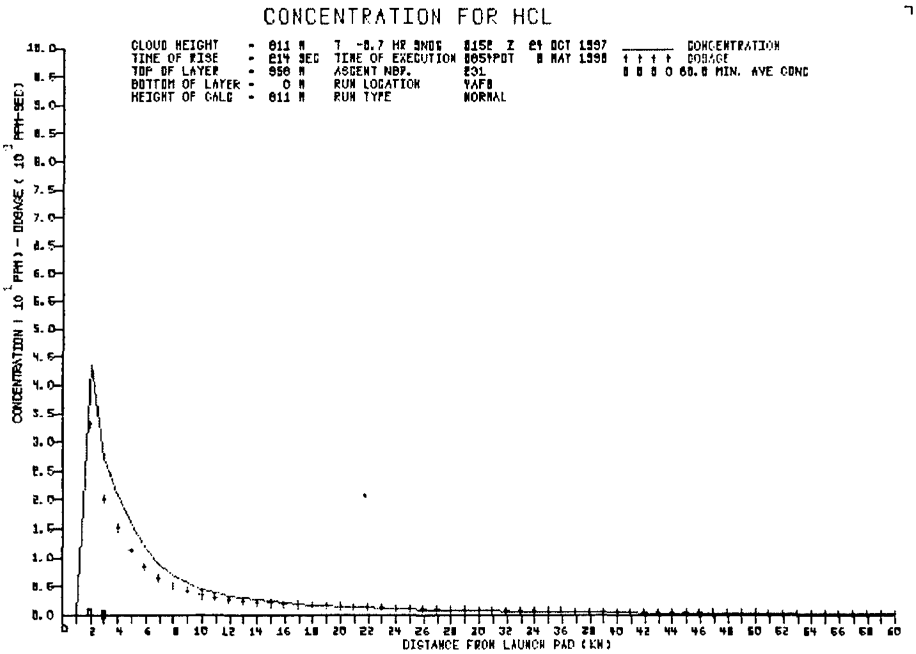


Figure 2A HCl Stabilization Height Concentration Predictions from REEDM Version 7.08 for A-18 Mission Using T-0.7h Rawinsonde Data.

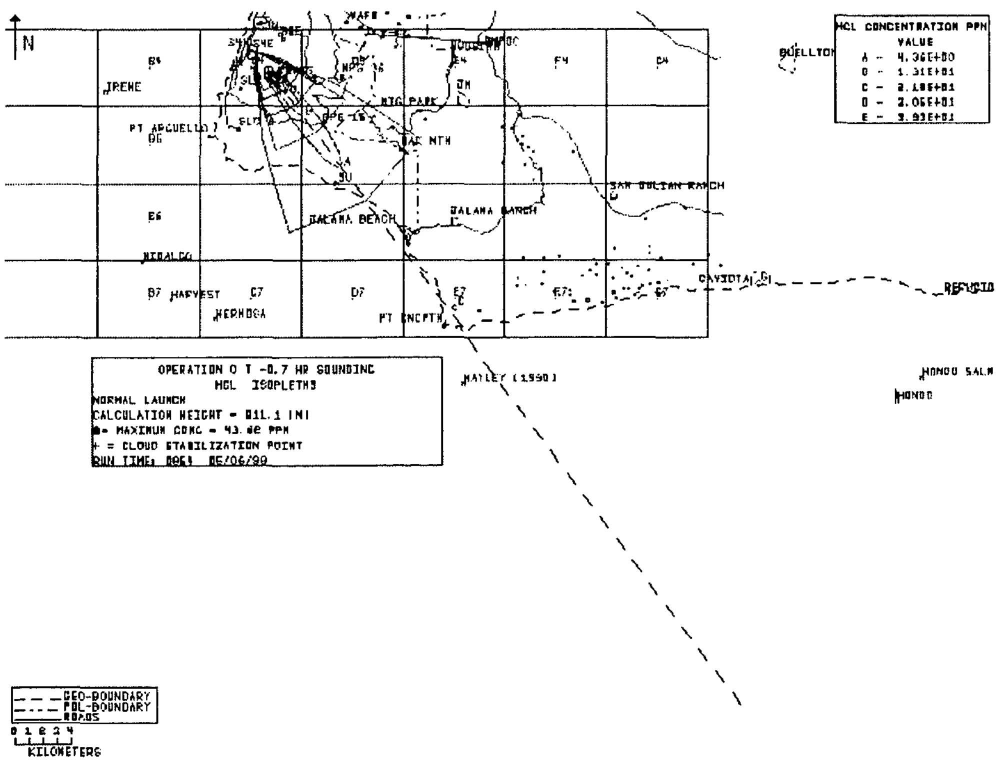


Figure 3A. HCl Stabilization Height Concentration Isopleth Predictions from REEDM Version 7.08 for A-18 Mission Using T-0.7 h Rawinsonde Data.

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1*****************************************************************************
              ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM         PAGE    1
                        VERSION 7.08 AT VAFB
                        0854 PDT  6 MAY 1998
                   launch time:  1932 PDT 23 OCT 1997
     RAWINSONDE ASCENT NUMBER    231, 0152   Z 24 OCT 1997  T  -0.7 HR
*****************************************************************************

                       ----- PROGRAM OPTIONS -----

 MODEL                                                         CONCENTRATION
 RUN TYPE                                                        OPERATIONAL
 WIND-FIELD TERRAIN EFFECTS MODEL                                       NONE
 LAUNCH VEHICLE                                                     TITAN IV
 LAUNCH TYPE                                                          NORMAL
 LAUNCH COMPLEX NUMBER                                                    4E
 TURBULENCE PARAMETERS ARE DETERMINED FROM               DOPPLER & TOWER DATA
 SURFACE CHEMISTRY MODEL                               absorption coefficient
 SPECIES      SURFACE FACTOR                                HCL        0.000
 CLOUD SHAPE                                                      ELLIPTICAL
 CALCULATION HEIGHT                                            STABILIZATION
 PROPELLANT TEMPERATURE (DEG. C)                                       14.67
 CONCENTRATION AVERAGING TIME (SEC.)                                 3600.00
 mixing layer reflection coefficient (RNG- 0 TO 1,no reflection=0)    1.0000
 DIFFUSION COEFFICIENTS                                  LATERAL      1.0000
                                                         VERTICAL     1.0000
 VEHICLE AIR ENTRAINMENT PARAMETER                       GAMMAE       0.6400
 DOWNWIND EXPANSION DISTANCE (METERS)                    LATERAL      100.00
                                                         VERTICAL     100.00

                          ----- DATA FILES -----

                              INPUT FILES
 RAWINSONDE FILE                                                 rm0152.297
 DATA BASE FILE                                                 rdmbase.vaf

                              OUTPUT FILES
 PRINT FILE                                                    a188_h0m.stb
 PLOT FILE                                                     a188_h0m.stp
```

1***

ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM PAGE 2
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----- METEOROLOGICAL RAWINSONDE DATA -----

TEST NBR SITE: 1764 OP NO: W0444 ASC NO: 231
RAWINSONDE MSS/WIN
TIME- 0152 Z DATE- 24 OCT 1997
ASCENT NUMBER 231

----- T -0.7 HR SOUNDING -----

MET. LEV. NO.	ALTITUDE MSL (FT)	GND (FT)	GND (M)	WIND DIR (DEG)	WIND SPEED (M/S)	(KTS)	TEMP	AIR PTEMP (DEG C)	DPTEMP	AIR PRESS (MB)	AIR RH (%)	H M	INT-ERP
1	328	0.0	0.0	335	5.7	11.0	15.5	16.8	11.7	1002.7	78.0		
2	383	54.9	16.7	343	6.7	13.0	15.3	16.7	11.7	1000.8	78.8		
3	431	102.9	31.4	333	7.2	14.0	15.2	16.8	11.6	999.0	79.5		
4	482	153.9	46.9	330	8.0	15.5	15.0	16.8	11.6	997.2	79.9		**
5	533	204.9	62.5	326	8.7	17.0	14.9	16.8	11.6	995.4	81.0		
6	581	252.9	77.1	335	8.7	17.0	14.8	16.8	11.6	993.6	81.2		**
7	629	300.9	91.7	343	8.7	17.0	14.6	16.8	11.5	991.9	82.4		
8	725	396.9	121.0	337	7.1	13.8	14.3	16.8	11.4	988.5	83.0		**
9	821	492.9	150.2	330	5.5	10.7	14.0	16.8	11.4	985.1	85.1		
10	985	656.9	200.2	326	6.3	12.3	13.5	16.8	11.4	979.3	87.5		
11	1149	820.9	250.2	330	7.0	13.7	13.0	16.7	11.3	973.5	89.9		
12	1294	965.9	294.4	327	7.6	14.7	12.5	16.7	11.2	968.5	92.0		
13	1468	1139.4	347.3	324	8.2	15.9	12.1	16.8	10.9	962.4	92.4		**
14	1641	1312.9	400.2	320	8.8	17.1	11.7	16.9	10.6	956.3	93.5		
15	1805	1476.9	450.2	330	9.0	17.5	11.3	16.9	10.3	950.6	94.2		
16	1969	1640.9	500.2	320	9.4	18.2	10.9	17.0	10.1	945.0	94.9		
17	2372	2043.9	623.0	320	9.6	18.7	9.9	17.2	9.4	931.2	96.6		
18	2879	2550.4	777.4	323	9.8	19.1	8.6	17.3	8.0	914.0	96.4		**
19	3385	3056.9	931.7	326	10.0	19.5	7.3	17.4	6.7	897.2	96.0		
20	3474	3145.9	958.9	339	12.5	24.3	7.6	17.5	-0.4	894.3	57.0	*	
21	3623	3294.9	1004.3	340	12.6	24.4	12.8	23.4	0.2	889.4	42.0		
22	4362	4033.9	1229.5	340	12.5	24.3	13.6	26.3	-3.9	865.9	29.4		
23	5350	5021.9	1530.7	332	13.8	26.8	13.0	28.7	-6.9	835.5	24.3		
24	5899	5570.4	1697.9	332	14.1	27.5	11.9	29.2	-7.2	819.0	26.3		**
25	6447	6118.9	1865.0	332	14.5	28.2	10.7	29.7	-7.5	802.8	27.1		
26	7410	7081.9	2158.6	332	14.5	28.2	8.4	30.3	-8.4	774.9	29.4		
27	7837	7508.9	2288.7	330	13.9	27.0	7.6	30.8	-8.8	762.8	30.0		
28	8066	7737.9	2358.5	325	12.8	24.9	9.2	33.2	-12.0	756.4	21.0		
29	8858	8529.4	2599.8	324	12.3	24.0	8.4	34.9	-12.6	734.7	22.1		**
30	9649	9320.9	2841.0	324	11.9	23.1	7.5	36.5	-13.3	713.5	21.2		
31	10200	9871.9	3009.0	323	12.0	23.3	6.5	37.2	-14.2	699.1	22.2		**

* - INDICATES THE CALCULATED TOP OF THE SURFACE MIXING LAYER
** - INDICATES THAT DATA IS LINEARLY INTERPOLATED FROM INPUT METEOROLOGY

SURFACE AIR DENSITY (GM/M**3) 1204.08
MIXING LAYER HEIGHT 958.88 (M) SPECIFIED BY PRESSURE LEVEL (MB) 894.11

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----- METEOROLOGICAL RAWINSONDE DATA -----

CLOUD COVER IN TENTHS OF CELESTIAL DOME	10.0
CLOUD CEILING (M)	762.0

***REEDM WARNING 09, END OF FILE READ, DATA MAY BE TRUNCATED, FILE = rm0152.297
THE ERROR OCCURRED AT RECORD 67.00

***REEDM ERROR 09, INCOMPLETE DATA - DOPPLER
THE ERROR OCCURRED AT RECORD 67.00

----- PLUME RISE DATA -----

EXHAUST RATE OF MATERIAL INTO GRN CLD-	(GRAMS/SEC)		4.15535E+06
TOTAL GROUND CLD MATERIAL-	(GRAMS)		3.91110E+07
HEAT OUTPUT PER GRAM-	(CALORIES)		1555.6
VEHICLE RISE HEIGHT DEFINING GROUND CLD-	(M)		199.9
VEHICLE RISE TIME PARAMETERS-	(TK=(A*Z**B)+C)	A=	0.8677
		B=	0.4500
		C=	0.0000
EXHAUST RATE OF MATERIAL INTO CONTRAIL-	(GRAMS/SEC)		4.15535E+06
CONTRAIL HEAT OUTPUT PER GRAM-	(CALORIES)		1555.6

1***

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****

----- EXHAUST CLOUD -----

MET. LAYER NO.	TOP OF LAYER (METERS)	CLOUD RISE TIME (SECONDS)	CLOUD RISE RANGE (METERS)	CLOUD RISE BEARING (DEGREES)	STABILIZED CLOUD RANGE (METERS)	STABILIZED CLOUD BEARING (DEGREES)
1	16.7	2.1	6.3	157.3	0.0	0.0
2	31.4	3.3	17.0	159.6	0.0	0.0
3	46.9	4.4	25.1	157.6	0.0	0.0
4	62.5	5.6	34.4	155.4	0.0	0.0
5	77.1	6.8	44.4	153.6	0.0	0.0
6	91.7	8.0	54.9	153.8	0.0	0.0
7	121.0	10.7	71.4	155.5	0.0	0.0
8	150.2	13.7	91.6	155.8	0.0	0.0
9	200.2	19.6	117.2	154.5	0.0	0.0
10	250.2	26.4	157.2	152.6	0.0	0.0
11	294.4	33.2	204.9	151.8	1532.0	149.0
12	347.3	42.2	264.5	150.7	1623.1	146.2
13	400.2	52.1	341.2	149.1	1721.3	143.2
14	450.2	62.3	428.3	147.6	1786.6	145.6
15	500.2	73.3	523.8	147.5	1824.0	145.7
16	623.0	104.6	721.5	145.6	1766.0	142.3
17	777.4	168.0	1176.5	143.6	1632.4	143.0
18	931.7	214.9 *	1948.0	143.3	1948.0	143.3
19	958.9	214.9 *	1948.0	143.3	1948.0	143.3
20	1004.3	214.9 *	1948.0	143.3	1948.0	143.3
21	1229.5	214.9 *	1948.0	143.3	1948.0	143.3
22	1530.7	214.9 *	1948.0	143.3	1948.0	143.3
23	1697.9	214.9 *	1948.0	143.3	1948.0	143.3
24	1865.0	214.9 *	1948.0	143.3	1948.0	143.3
25	2158.6	214.9 *	1948.0	143.3	1948.0	143.3
26	2288.7	214.9 *	1948.0	143.3	1948.0	143.3
27	2358.5	214.9 *	1948.0	143.3	1948.0	143.3
28	2599.8	214.9 *	1948.0	143.3	1948.0	143.3
29	2841.0	214.9 *	1948.0	143.3	1948.0	143.3
30	3009.0	214.9 *	1948.0	143.3	1948.0	143.3

* - INDICATES CLOUD STABILIZATION TIME WAS USED

----- EXHAUST CLOUD -----

CHEMICAL SPECIES = HCL

MET. LAYER NO.	TOP OF LAYER (METERS)		LAYER SOURCE STRENGTH (GRAMS)	CLOUD UPDRAFT VELOCITY (M/S)	CLOUD RADIUS (METERS)	STD. DEVIATION MATERIAL DIST. ALONGWIND (METERS)	CROSSWIND (METERS)
1	16.7		0.00000E+00	12.2	0.0	0.0	0.0
2	31.4		0.00000E+00	13.5	0.0	0.0	0.0
3	46.9		0.00000E+00	13.4	0.0	0.0	0.0
4	62.5		0.00000E+00	12.8	0.0	0.0	0.0
5	77.1		0.00000E+00	12.2	0.0	0.0	0.0
6	91.7		0.00000E+00	11.5	0.0	0.0	0.0
7	121.0		0.00000E+00	10.3	0.0	0.0	0.0
8	150.2		0.00000E+00	9.2	0.0	0.0	0.0
9	200.2		0.00000E+00	7.8	0.0	0.0	0.0
10	250.2		0.00000E+00	6.9	0.0	0.0	0.0
11	294.4		1.25596E+02	6.2	167.0	77.8	77.8
12	347.3		1.16641E+05	5.6	192.1	89.5	89.5
13	400.2		3.19435E+05	5.1	317.1	147.7	147.7
14	450.2		4.67517E+05	4.7	394.3	183.7	183.7
15	500.2		6.08527E+05	4.4	449.7	209.6	209.6
16	623.0		1.97109E+06	3.4	517.6	241.2	241.2
17	777.4		3.07156E+06	1.4	576.8	268.8	268.8
18	931.7	*	4.13238E+06	0.0	588.4	274.2	274.2
19	958.9	*	7.32699E+05	0.0	570.4	265.8	265.8
20	1004.3	*	1.18016E+06	0.0	557.7	259.9	259.9
21	1229.5	*	4.53714E+06	0.0	476.9	222.2	222.2
22	1530.7	*	2.19462E+06	0.0	348.7	162.5	162.5
23	1697.9	*	9.23037E+05	0.0	199.9	93.2	93.2
24	1865.0	*	8.74277E+05	0.0	199.9	93.2	93.2
25	2158.6	*	1.43629E+06	0.0	199.9	93.2	93.2
26	2288.7	*	6.02356E+05	0.0	199.9	93.2	93.2
27	2358.5	*	3.15295E+05	0.0	199.9	93.2	93.2
28	2599.8	*	1.05193E+06	0.0	199.9	93.2	93.2
29	2841.0	*	9.99494E+05	0.0	199.9	93.2	93.2
30	3009.0	*	6.68480E+05	0.0	199.9	93.2	93.2

* - INDICATES CLOUD STABILIZATION TIME WAS USED

----- CLOUD STABILIZATION -----

CALCULATION HEIGHT	(METERS)		811.14
STABILIZATION HEIGHT	(METERS)		811.14
STABILIZATION TIME	(SECS)		214.90
FIRST MIXING LAYER HEIGHT-	(METERS)	TOP =	958.88
		BASE=	0.00
SECOND SELECTED LAYER HEIGHT-	(METERS)	TOP =	3008.96
		BASE=	958.88
SIGMAR(AZ) AT THE SURFACE	(DEGREES)		5.7504
SIGMER(EL) AT THE SURFACE	(DEGREES)		1.0344

MET. LAYER NO.	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIRECTION (DEG)	WIND DIRECTION SHEAR (DEG)	SIGMA OF AZI ANG (DEG)	SIGMA OF ELE ANG (DEG)
1	6.38	1.03	339.00	8.00	5.3966	1.4248
2	6.94	0.51	338.00	-10.00	4.8750	2.2148
3	7.59	0.77	331.25	-3.50	4.2593	3.0144
4	8.36	0.77	327.75	-3.50	4.0129	3.8143
5	8.75	0.00	330.25	8.50	4.5893	4.5893
6	8.75	0.00	338.75	8.50	5.3322	5.3322
7	7.94	1.62	339.75	-6.50	8.8074	8.8074
8	6.31	1.62	333.25	-6.50	16.1653	16.1653
9	5.92	0.82	328.00	-4.00	12.9349	12.9349
10	6.69	0.72	328.00	4.00	10.2701	10.2701
11	7.31	0.51	328.55	-2.90	13.9863	13.9863
12	7.87	0.62	325.33	-3.55	11.6115	11.6115
13	8.49	0.62	321.77	-3.55	9.0613	9.0613
14	8.90	0.21	325.00	10.00	6.5363	6.5363
15	9.18	0.36	325.00	-10.00	4.0918	4.0918
16	9.49	0.26	320.00	0.00	2.2483	2.2483
17	9.72	0.21	321.45	2.90	1.4745	1.4745
18	9.93	0.21	324.35	2.90	1.2243	1.2243
19	11.27	2.47	332.20	12.80	1.0495	1.0495
20	12.53	0.05	339.30	1.40	1.0000	1.0000
21	12.53	-0.05	339.85	-0.30	1.0000	1.0000
22	13.14	1.29	335.75	-7.90	1.0000	1.0000
23	13.97	0.36	331.75	-0.10	1.0000	1.0000
24	14.33	0.36	331.65	-0.10	1.0000	1.0000
25	14.51	0.00	331.65	0.10	1.0000	1.0000
26	14.20	-0.62	330.80	-1.80	1.0000	1.0000
27	13.35	-1.08	327.45	-4.90	1.0000	1.0000
28	12.58	-0.46	324.67	-0.65	1.0000	1.0000
29	12.12	-0.46	324.03	-0.65	1.0000	1.0000
30	11.95	0.13	323.55	-0.30	1.0000	1.0000

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----- CALCULATED TRANSITION LAYER PARAMETERS -----

ALTITUDE RANGE USED IN COMPUTING TRANSITION LAYER AVERAGES
IS 150.2 TO 3009.0 METERS.

TRANSITION LAYER NUMBER- 1

VALUE AT	HEIGHT (METERS)	TEMP. (DEG K)	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIR. (DEG)	WIND DIR. SHEAR (DEG)	SIGMA AZI. (DEG)	SIGMA ELE. (DEG)
TOP-	958.88	290.67	12.50		338.60		1.0000	1.0000
LAYER-			8.92	1.42	323.86	5.24	5.0998	5.0998
BOTTOM-	0.00	289.93	5.66		335.00		5.7504	1.0344

TRANSITION LAYER NUMBER- 2

VALUE AT	HEIGHT (METERS)	TEMP. (DEG K)	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIR. (DEG)	WIND DIR. SHEAR (DEG)	SIGMA AZI. (DEG)	SIGMA ELE. (DEG)
TOP-	3008.96	310.38	12.01		323.40		1.0000	1.0000
LAYER-			13.15	1.01	330.87	5.26	1.0000	1.0000
BOTTOM-	958.88	290.67	12.50		338.60		1.0000	1.0000

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****

----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 811.1 METERS
DOWNWIND FROM A TITAN IV NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 958.9 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	PEAK CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
2000.0867	143.3266	43.6164	2.4068	4.7800
3000.0391	143.5673	27.1230	2.5596	6.6514
4000.0088	143.7395	20.6283	4.4091	8.5301
5000.0430	143.6222	15.5533	6.2488	10.4156
6000.0283	143.6834	11.6719	8.0799	12.3078
7000.0000	143.8469	8.8666	9.9033	14.2061
8000.0347	143.6913	6.9036	11.7202	16.1102
9000.0127	143.9573	5.5418	13.5315	18.0194
10000.0000	143.8637	4.5949	15.3383	19.9335
11000.0088	143.7871	3.9121	17.1411	21.8517
12000.0342	143.7233	3.3977	18.9408	23.7738
13000.0723	143.6693	2.9922	20.7377	25.6992
14000.0557	144.0215	2.6595	22.5324	27.6276
15000.0342	143.9828	2.3822	24.3252	29.5587
16000.0195	143.9489	2.1451	26.1164	31.4921
17000.0098	143.9190	1.9404	27.9062	33.4276
18000.0020	143.8924	1.7624	29.6948	35.3649
19000.0000	143.8687	1.6067	31.4824	37.3039
20000.0000	143.8472	1.4698	33.2691	39.2443
21000.0039	143.8279	1.3490	35.0526	41.1860
22000.0078	143.8103	1.2419	36.8356	43.1289
23000.0156	143.7942	1.1466	38.6182	45.0729
24000.0234	143.7795	1.0615	40.4004	47.0178
25000.0332	143.7659	0.9852	42.1823	48.9635
26000.3594	144.1616	0.9149	43.9640	50.9100
27000.3477	144.1504	0.8533	45.7454	52.8571
28000.3340	144.1400	0.7976	47.5266	54.8049
29000.3223	144.1304	0.7470	49.3075	56.7533
30000.3125	144.1214	0.7009	51.0883	58.7021
31000.3027	144.1129	0.6589	52.8690	60.6515
32000.2930	144.1050	0.6204	54.6495	62.6013
33000.2852	144.0976	0.5852	56.4298	64.5515
34000.2734	144.0906	0.5528	58.2101	66.5020
35000.2656	144.0840	0.5230	59.9902	68.4529
36000.2617	144.0778	0.4955	61.7702	70.4041

VERSION 7.08 AT VAFB
0854 PDT 6 MAY 1998
launch time: 1932 PDT 23 OCT 1997
RAWINSONDE ASCENT NUMBER 231, 0152 Z 24 OCT 1997 T -0.7 HR
****

----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 811.1 METERS
DOWNWIND FROM A TITAN IV NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 958.9 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	PEAK CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
37000.2539	144.0719	0.4701	63.5501	72.3555
38000.2461	144.0664	0.4466	65.3300	74.3073
39000.2383	144.0611	0.4247	67.1098	76.2593
40000.2344	144.0560	0.4044	68.8895	78.2115
41000.2266	144.0513	0.3855	70.6691	80.1639
42000.2227	144.0467	0.3679	72.4486	82.1165
43000.2188	144.0424	0.3514	74.2282	84.0693
44000.2109	144.0382	0.3360	76.0076	86.0223
45000.2070	144.0343	0.3216	77.7870	87.9755
46000.2031	144.0305	0.3081	79.5664	89.9288
47000.1992	144.0268	0.2954	81.3457	91.8822
48000.1953	144.0234	0.2835	83.1250	93.8358
49000.1914	144.0200	0.2722	84.9042	95.7894
50000.1875	144.0168	0.2617	86.6834	97.7433
51000.1836	144.0138	0.2517	88.4626	99.6972
52000.1797	144.0108	0.2423	90.2417	101.6512
53000.1758	144.0079	0.2334	92.0208	103.6054
54000.1719	144.0052	0.2249	93.7999	105.5596
55000.1719	144.0026	0.2169	95.5789	107.5139
56000.1680	144.0000	0.2094	97.3579	109.4683
57000.1641	143.9976	0.2022	99.1369	111.4227
58000.1602	143.9952	0.1954	100.9159	113.3773
59000.1602	143.9929	0.1889	102.6949	115.3319
60000.1563	143.9907	0.1827	104.4738	117.2866

	RANGE	BEARING
43.616 IS THE MAXIMUM PEAK CONCENTRATION	2000.1	143.3

VERSION 7.08 AT VAFB
0854 PDT 6 MAY 1998
launch time: 1932 PDT 23 OCT 1997
RAWINSONDE ASCENT NUMBER 231, 0152 Z 24 OCT 1997 T -0.7 HR
****

----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 811.1 METERS
DOWNWIND FROM A TITAN IV NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 958.9 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	60.0 MIN. MEAN CONCEN- TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
2000.0867	143.3266	0.9313	2.4068	4.7800
3000.0391	143.5673	0.5759	2.5596	6.6514
4000.0088	143.7395	0.4342	4.4091	8.5301
5000.0430	143.6222	0.3276	6.2488	10.4156
6000.0283	143.6834	0.2491	8.0799	12.3078
7000.0000	143.8469	0.1936	9.9033	14.2061
8000.0347	143.6913	0.1553	11.7202	16.1102
9000.1152	143.5703	0.1292	13.5315	18.0194
10000.0000	143.8637	0.1114	15.3383	19.9335
11000.0088	143.7871	0.0990	17.1411	21.8517
12000.0342	143.7233	0.0898	18.9408	23.7738
13000.0723	143.6693	0.0827	20.7377	25.6992
14000.0557	144.0215	0.0769	22.5324	27.6276
15000.0342	143.9828	0.0720	24.3252	29.5587
16000.0195	143.9489	0.0677	26.1164	31.4921
17000.0098	143.9190	0.0639	27.9062	33.4276
18000.0020	143.8924	0.0605	29.6948	35.3649
19000.0000	143.8687	0.0575	31.4824	37.3039
20000.0000	143.8472	0.0547	33.2691	39.2443
21000.0039	143.8279	0.0522	35.0526	41.1860
22000.0078	143.8103	0.0500	36.8356	43.1289
23000.0156	143.7942	0.0479	38.6182	45.0729
24000.0234	143.7795	0.0459	40.4004	47.0178
25000.0332	143.7659	0.0442	42.1823	48.9635
26000.3594	144.1616	0.0424	43.9640	50.9100
27000.3477	144.1504	0.0409	45.7454	52.8571
28000.3340	144.1400	0.0395	47.5266	54.8049
29000.3223	144.1304	0.0382	49.3075	56.7533
30000.3125	144.1214	0.0370	51.0883	58.7021
31000.3027	144.1129	0.0358	52.8690	60.6515
32000.2930	144.1050	0.0347	54.6495	62.6013
33000.2852	144.0976	0.0337	56.4298	64.5515
34000.2734	144.0906	0.0327	58.2101	66.5020
35000.2656	144.0840	0.0318	59.9902	68.4529

----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 811.1 METERS
DOWNWIND FROM A TITAN IV NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 958.9 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	60.0 MIN. MEAN CONCEN- TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
36000.2617	144.0778	0.0310	61.7702	70.4041
37000.2539	144.0719	0.0302	63.5501	72.3555
38000.2461	144.0664	0.0294	65.3300	74.3073
39000.2383	144.0611	0.0286	67.1098	76.2593
40000.2344	144.0560	0.0279	68.8895	78.2115
41000.2266	144.0513	0.0273	70.6691	80.1639
42000.2227	144.0467	0.0266	72.4486	82.1165
43000.2188	144.0424	0.0260	74.2282	84.0693
44000.2109	144.0382	0.0255	76.0076	86.0223
45000.2070	144.0343	0.0249	77.7870	87.9755
46000.2031	144.0305	0.0244	79.5664	89.9288
47000.1992	144.0268	0.0239	81.3457	91.8822
48000.1953	144.0234	0.0234	83.1250	93.8358
49000.1914	144.0200	0.0229	84.9042	95.7894
50000.1875	144.0168	0.0225	86.6834	97.7433
51000.1836	144.0138	0.0220	88.4626	99.6972
52000.1797	144.0108	0.0216	90.2417	101.6512
53000.1758	144.0079	0.0212	92.0208	103.6054
54000.1719	144.0052	0.0208	93.7999	105.5596
55000.1719	144.0026	0.0205	95.5789	107.5139
56000.1680	144.0000	0.0201	97.3579	109.4683
57000.1641	143.9976	0.0197	99.1369	111.4227
58000.1602	143.9952	0.0194	100.9159	113.3773
59000.1602	143.9929	0.0191	102.6949	115.3319
60000.1563	143.9907	0.0188	104.4738	117.2866

	RANGE	BEARING
0.931 IS THE MAXIMUM 60.0 MIN. MEAN CONCENTRATION	2000.1	143.3

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1*******************************************************************************
              ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM        PAGE  12
                          VERSION 7.08 AT VAFB
                          0854 PDT  6 MAY 1998
                   launch time:  1932 PDT 23 OCT 1997
     RAWINSONDE ASCENT NUMBER    231, 0152   Z 24 OCT 1997  T  -0.7 HR
 *******************************************************************************

               ----- hazard box coordinates -----


 HAZARD BOX COORDINATES FOR HCL        CONCENTRATION
        SCENARIO =          NORMAL         MET PROFILE = T  -0.7 HR
        DIRECTIONAL UNCERTAINTY =   25.0  RANGE EXTENSTION FACTOR =    1.3
        SOURCE LOCATION =  34 37 55  120 36 45

 ISOPLETH # 1 VALUE = 4.3616E+00  PPM
 CRASH GRID COORDINATES:
 17 BU   36 BM   55 AY   42 AK   41 AK   24 AD   18 BA   17 BU
 RANGE(NMI) AND BEARING(DEG), LAT(DMS) AND LONG(DMS) :
      3.4  111.      7.2  118.      7.2  143.
      3.4  176.      7.2  169.      7.2  144.
    34 36 35  120 32 54    34 34 19  120 29  8    34 32  0  120 31 42
    34 34 29  120 36 34    34 30 46  120 35 19    34 31 57  120 31 48

 ISOPLETH # 2 VALUE = 1.3085E+01  PPM
 CRASH GRID COORDINATES:
 17 BU   23 BS   38 BI   31 BB   30 BB   21 AX   17 BO   17 BU
 RANGE(NMI) AND BEARING(DEG), LAT(DMS) AND LONG(DMS) :
      1.1  106.      3.9  118.      3.9  144.
      1.1  181.      3.9  169.      3.9  144.
    34 37 36  120 35 27    34 35 58  120 32 37    34 34 42  120 34  0
    34 36 49  120 36 48    34 34  2  120 35 56    34 34 41  120 34  1

 ISOPLETH # 3 VALUE = 2.1808E+01  PPM
 CRASH GRID COORDINATES:
 17 BU   23 BS   31 BN   26 BI   26 BH   19 BF   17 BO   17 BU
 RANGE(NMI) AND BEARING(DEG), LAT(DMS) AND LONG(DMS) :
      1.1  109.      2.6  117.      2.6  143.
      1.1  178.      2.6  170.      2.6  145.
    34 37 33  120 35 30    34 36 40  120 33 59    34 35 49  120 34 54
    34 36 49  120 36 44    34 35 21  120 36 16    34 35 46  120 34 59

 ISOPLETH # 4 VALUE = 3.0531E+01  PPM
 CRASH GRID COORDINATES:
 17 BU   23 BS   27 BP   24 BL   23 BL   19 BJ   17 BO   17 BU
 RANGE(NMI) AND BEARING(DEG), LAT(DMS) AND LONG(DMS) :
      1.1  111.      1.9  117.      1.9  142.
      1.1  175.      1.9  170.      1.9  145.
    34 37 30  120 35 31    34 37  1  120 34 43    34 36 23  120 35 23
    34 36 50  120 36 40    34 36  2  120 36 24    34 36 21  120 35 27
```

```
                    ----- hazard box coordinates -----

 ISOPLETH # 5 VALUE = 3.9255E+01   PPM
 CRASH GRID COORDINATES:
 17 BU    23 BS    25 BQ    22 BN    18 BL    18 BO    17 BU
 RANGE(NMI) AND BEARING(DEG), LAT(DMS) AND LONG(DMS) :
      1.1  115.       1.5  117.       1.5  143.
      1.1  172.       1.5  169.       1.5  144.
   34 37 27  120 35 34    34 37 11  120 35  6    34 36 40  120 35 38
   34 36 50  120 36 36    34 36 23  120 36 27    34 36 39  120 35 41

 *** REEDM  HAS TERMINATED
```

Surface Impact Predictions

This section includes the REEDM version 7.08 output for the surface impact run. For the surface impact run, we included the plots of the rawinsonde meteorological data, the predicted maximum concentration versus downwind distance, and the predicted concentration isopleths overlayed on a range map. The rawinsonde meteorological data is identical to the data plotted in Figure for the stabilization height run. Lastly this section includes the detailed REEDM report for this run.

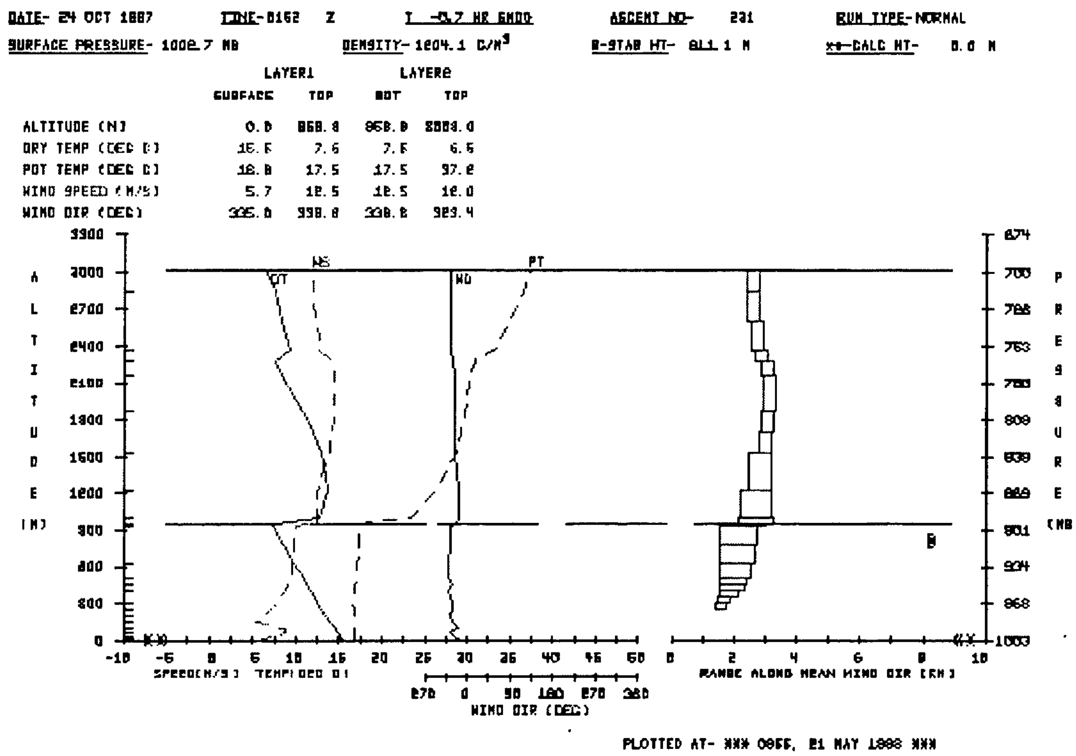

Figure 4A. Meteorological Output Plot from REEDM Version 7.08 for A-18 Mission Using T-0.7 h Rawinsonde Data.

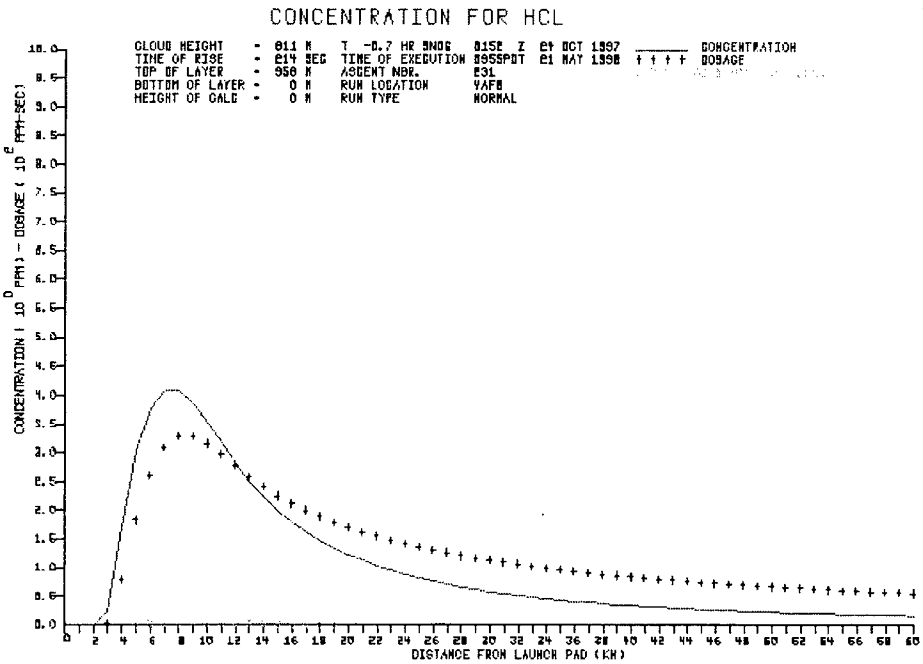

Figure 5A. HCl Surface Height Concentration Predictions from REEDM Version 7.08 for A-18 Mission Using T-0.7 h Rawinsonde Data.

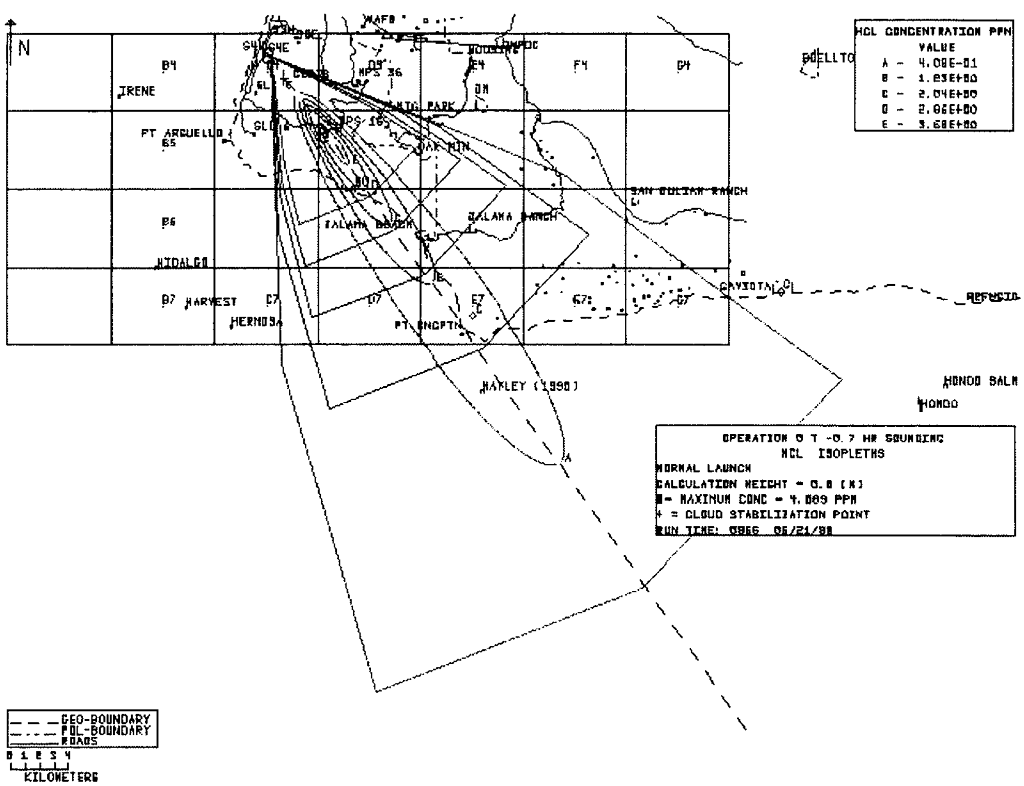

Figure 6A. HCl Surface Height Concentration Isopleth Predictions from REEDM Version 7.08 for A-18 Mission Using T-0.7h Rawinsonde Data.

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1*************************************************************************
               ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM        PAGE    1
                         VERSION 7.08 AT VAFB
                         0955 PDT 21 MAY 1998
                    launch time:  1932 PDT 23 OCT 1997
     RAWINSONDE ASCENT NUMBER    231, 0152   Z 24 OCT 1997  T  -0.7 HR
*************************************************************************

                      ----- PROGRAM OPTIONS -----

 MODEL                                                       CONCENTRATION
 RUN TYPE                                                      OPERATIONAL
 WIND-FIELD TERRAIN EFFECTS MODEL                                     NONE
 LAUNCH VEHICLE                                                   TITAN IV
 LAUNCH TYPE                                                        NORMAL
 LAUNCH COMPLEX NUMBER                                                  4E
 TURBULENCE PARAMETERS ARE DETERMINED FROM             DOPPLER & TOWER DATA
 SURFACE CHEMISTRY MODEL                            absorption coefficient
 SPECIES      SURFACE FACTOR                           HCL           0.000
 CLOUD SHAPE                                                    ELLIPTICAL
 CALCULATION HEIGHT                                                SURFACE
 PROPELLANT TEMPERATURE (DEG. C)                                     14.67
 CONCENTRATION AVERAGING TIME (SEC.)                               3600.00
 mixing layer reflection coefficient (RNG- 0 TO 1,no reflection=0)  1.0000
 DIFFUSION COEFFICIENTS                               LATERAL       1.0000
                                                      VERTICAL      1.0000
 VEHICLE AIR ENTRAINMENT PARAMETER                    GAMMAE        0.6400
 DOWNWIND EXPANSION DISTANCE (METERS)                 LATERAL       100.00
                                                      VERTICAL      100.00

                         ----- DATA FILES -----

                              INPUT FILES
 RAWINSONDE FILE                                                rm0152.297
 DATA BASE FILE                                                rdmbase.vaf

                              OUTPUT FILES
 PRINT FILE                                                   a188_h0m.sur
 PLOT FILE                                                    a188_h0m.sup
```

1***

ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM PAGE 2

VERSION 7.08 AT VAFB

0955 PDT 21 MAY 1998

launch time: 1932 PDT 23 OCT 1997

RAWINSONDE ASCENT NUMBER 231, 0152 Z 24 OCT 1997 T -0.7 HR

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----- METEOROLOGICAL RAWINSONDE DATA -----

TEST NBR SITE: 1764 OP NO: W0444 ASC NO: 231

RAWINSONDE MSS/WIN

TIME- 0152 Z DATE- 24 OCT 1997

ASCENT NUMBER 231

----- T -0.7 HR SOUNDING -----

MET. LEV. NO.	MSL (FT)	ALTITUDE GND (FT)	GND (M)	WIND DIR (DEG)	WIND SPEED (M/S)	(KTS)	TEMP	AIR PTEMP (DEG C)	DPTEMP	AIR PRESS (MB)	AIR RH (%)	H M	INT- ERP
1	328	0.0	0.0	335	5.7	11.0	15.5	16.8	11.7	1002.7	78.0		
2	383	54.9	16.7	343	6.7	13.0	15.3	16.7	11.7	1000.8	78.8		
3	431	102.9	31.4	333	7.2	14.0	15.2	16.8	11.6	999.0	79.5		
4	482	153.9	46.9	330	8.0	15.5	15.0	16.8	11.6	997.2	79.9		**
5	533	204.9	62.5	326	8.7	17.0	14.9	16.8	11.6	995.4	81.0		
6	581	252.9	77.1	335	8.7	17.0	14.8	16.8	11.6	993.6	81.2		**
7	629	300.9	91.7	343	8.7	17.0	14.6	16.8	11.5	991.9	82.4		
8	725	396.9	121.0	337	7.1	13.8	14.3	16.8	11.4	988.5	83.0		**
9	821	492.9	150.2	330	5.5	10.7	14.0	16.8	11.4	985.1	85.1		
10	985	656.9	200.2	326	6.3	12.3	13.5	16.8	11.4	979.3	87.5		
11	1149	820.9	250.2	330	7.0	13.7	13.0	16.7	11.3	973.5	89.9		
12	1294	965.9	294.4	327	7.6	14.7	12.5	16.7	11.2	968.5	92.0		
13	1468	1139.4	347.3	324	8.2	15.9	12.1	16.8	10.9	962.4	92.4		**
14	1641	1312.9	400.2	320	8.8	17.1	11.7	16.9	10.6	956.3	93.5		
15	1805	1476.9	450.2	330	9.0	17.5	11.3	16.9	10.3	950.6	94.2		
16	1969	1640.9	500.2	320	9.4	18.2	10.9	17.0	10.1	945.0	94.9		
17	2372	2043.9	623.0	320	9.6	18.7	9.9	17.2	9.4	931.2	96.6		
18	2879	2550.4	777.4	323	9.8	19.1	8.6	17.3	8.0	914.0	96.4		**
19	3385	3056.9	931.7	326	10.0	19.5	7.3	17.4	6.7	897.2	96.0		
20	3474	3145.9	958.9	339	12.5	24.3	7.6	17.5	-0.4	894.3	57.0	*	
21	3623	3294.9	1004.3	340	12.6	24.4	12.8	23.4	0.2	889.4	42.0		
22	4362	4033.9	1229.5	340	12.5	24.3	13.6	26.3	-3.9	865.9	29.4		
23	5350	5021.9	1530.7	332	13.8	26.8	13.0	28.7	-6.9	835.5	24.3		
24	5899	5570.4	1697.9	332	14.1	27.5	11.9	29.2	-7.2	819.0	26.3		**
25	6447	6118.9	1865.0	332	14.5	28.2	10.7	29.7	-7.5	802.8	27.1		
26	7410	7081.9	2158.6	332	14.5	28.2	8.4	30.3	-8.4	774.9	29.4		
27	7837	7508.9	2288.7	330	13.9	27.0	7.6	30.8	-8.8	762.8	30.0		
28	8066	7737.9	2358.5	325	12.8	24.9	9.2	33.2	-12.0	756.4	21.0		
29	8858	8529.4	2599.8	324	12.3	24.0	8.4	34.9	-12.6	734.7	22.1		**
30	9649	9320.9	2841.0	324	11.9	23.1	7.5	36.5	-13.3	713.5	21.2		
31	10200	9871.9	3009.0	323	12.0	23.3	6.5	37.2	-14.2	699.1	22.2		**

* - INDICATES THE CALCULATED TOP OF THE SURFACE MIXING LAYER

** - INDICATES THAT DATA IS LINEARLY INTERPOLATED FROM INPUT METEOROLOGY

SURFACE AIR DENSITY (GM/M**3) 1204.08

MIXING LAYER HEIGHT 958.88 (M) SPECIFIED BY PRESSURE LEVEL (MB) 894.11

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1*****************************************************************************
              ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM        PAGE    3
                          VERSION 7.08 AT VAFB
                          0955 PDT 21 MAY 1998
                   launch time:  1932 PDT 23 OCT 1997
     RAWINSONDE ASCENT NUMBER    231, 0152   Z 24 OCT 1997  T  -0.7 HR
*****************************************************************************

                ----- METEOROLOGICAL RAWINSONDE DATA -----

 CLOUD COVER IN TENTHS OF CELESTIAL DOME                                 10.0
 CLOUD CEILING (M)                                                      762.0

***REEDM  WARNING 09, END OF FILE READ, DATA MAY BE TRUNCATED, FILE =
                  rm0152.297
                    THE ERROR OCCURRED AT RECORD   67.00

***REEDM  ERROR 09, INCOMPLETE DATA - DOPPLER
                    THE ERROR OCCURRED AT RECORD   67.00
                        ----- PLUME RISE DATA -----

EXHAUST RATE OF MATERIAL INTO GRN CLD-   (GRAMS/SEC)           4.15535E+06
TOTAL GROUND CLD MATERIAL-               (GRAMS)               3.91110E+07
HEAT OUTPUT PER GRAM-                    (CALORIES)                 1555.6
VEHICLE RISE HEIGHT DEFINING GROUND CLD- (M)                         199.9
VEHICLE RISE TIME PARAMETERS-            (TK=(A*Z**B)+C)  A=        0.8677
                                                          B=        0.4500
                                                          C=        0.0000
EXHAUST RATE OF MATERIAL INTO CONTRAIL-  (GRAMS/SEC)           4.15535E+06
CONTRAIL HEAT OUTPUT PER GRAM-           (CALORIES)                 1555.6
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ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM PAGE 4
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----- EXHAUST CLOUD -----

MET. LAYER NO.	TOP OF LAYER (METERS)	CLOUD RISE TIME (SECONDS)	CLOUD RISE RANGE (METERS)	CLOUD RISE BEARING (DEGREES)	STABILIZED CLOUD RANGE (METERS)	STABILIZED CLOUD BEARING (DEGREES)
1	16.7	2.1	6.3	157.3	0.0	0.0
2	31.4	3.3	17.0	159.6	0.0	0.0
3	46.9	4.4	25.1	157.6	0.0	0.0
4	62.5	5.6	34.4	155.4	0.0	0.0
5	77.1	6.8	44.4	153.6	0.0	0.0
6	91.7	8.0	54.9	153.8	0.0	0.0
7	121.0	10.7	71.4	155.5	0.0	0.0
8	150.2	13.7	91.6	155.8	0.0	0.0
9	200.2	19.6	117.2	154.5	0.0	0.0
10	250.2	26.4	157.2	152.6	0.0	0.0
11	294.4	33.2	204.9	151.8	1532.0	149.0
12	347.3	42.2	264.5	150.7	1623.1	146.2
13	400.2	52.1	341.2	149.1	1721.3	143.2
14	450.2	62.3	428.3	147.6	1786.6	145.6
15	500.2	73.3	523.8	147.5	1824.0	145.7
16	623.0	104.6	721.5	145.6	1766.0	142.3
17	777.4	168.0	1176.5	143.6	1632.4	143.0
18	931.7	214.9 *	1948.0	143.3	1948.0	143.3
19	958.9	214.9 *	1948.0	143.3	1948.0	143.3
20	1004.3	214.9 *	1948.0	143.3	1948.0	143.3
21	1229.5	214.9 *	1948.0	143.3	1948.0	143.3
22	1530.7	214.9 *	1948.0	143.3	1948.0	143.3
23	1697.9	214.9 *	1948.0	143.3	1948.0	143.3
24	1865.0	214.9 *	1948.0	143.3	1948.0	143.3
25	2158.6	214.9 *	1948.0	143.3	1948.0	143.3
26	2288.7	214.9 *	1948.0	143.3	1948.0	143.3
27	2358.5	214.9 *	1948.0	143.3	1948.0	143.3
28	2599.8	214.9 *	1948.0	143.3	1948.0	143.3
29	2841.0	214.9 *	1948.0	143.3	1948.0	143.3
30	3009.0	214.9 *	1948.0	143.3	1948.0	143.3

* - INDICATES CLOUD STABILIZATION TIME WAS USED

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----- EXHAUST CLOUD -----

CHEMICAL SPECIES = HCL

MET. LAYER NO.	TOP OF LAYER (METERS)		LAYER SOURCE STRENGTH (GRAMS)	CLOUD UPDRAFT VELOCITY (M/S)	CLOUD RADIUS (METERS)	STD. DEVIATION MATERIAL DIST. ALONGWIND (METERS)	CROSSWIND (METERS)
1	16.7		0.00000E+00	12.2	0.0	0.0	0.0
2	31.4		0.00000E+00	13.5	0.0	0.0	0.0
3	46.9		0.00000E+00	13.4	0.0	0.0	0.0
4	62.5		0.00000E+00	12.8	0.0	0.0	0.0
5	77.1		0.00000E+00	12.2	0.0	0.0	0.0
6	91.7		0.00000E+00	11.5	0.0	0.0	0.0
7	121.0		0.00000E+00	10.3	0.0	0.0	0.0
8	150.2		0.00000E+00	9.2	0.0	0.0	0.0
9	200.2		0.00000E+00	7.8	0.0	0.0	0.0
10	250.2		0.00000E+00	6.9	0.0	0.0	0.0
11	294.4		1.25596E+02	6.2	167.0	77.8	77.8
12	347.3		1.16641E+05	5.6	192.1	89.5	89.5
13	400.2		3.19435E+05	5.1	317.1	147.7	147.7
14	450.2		4.67517E+05	4.7	394.3	183.7	183.7
15	500.2		6.08527E+05	4.4	449.7	209.6	209.6
16	623.0		1.97109E+06	3.4	517.6	241.2	241.2
17	777.4		3.07156E+06	1.4	576.8	268.8	268.8
18	931.7	*	4.13238E+06	0.0	588.4	274.2	274.2
19	958.9	*	7.32699E+05	0.0	570.4	265.8	265.8
20	1004.3	*	1.18016E+06	0.0	557.7	259.9	259.9
21	1229.5	*	4.53714E+06	0.0	476.9	222.2	222.2
22	1530.7	*	2.19462E+06	0.0	348.7	162.5	162.5
23	1697.9	*	9.23037E+05	0.0	199.9	93.2	93.2
24	1865.0	*	8.74277E+05	0.0	199.9	93.2	93.2
25	2158.6	*	1.43629E+06	0.0	199.9	93.2	93.2
26	2288.7	*	6.02356E+05	0.0	199.9	93.2	93.2
27	2358.5	*	3.15295E+05	0.0	199.9	93.2	93.2
28	2599.8	*	1.05193E+06	0.0	199.9	93.2	93.2
29	2841.0	*	9.99494E+05	0.0	199.9	93.2	93.2
30	3009.0	*	6.68480E+05	0.0	199.9	93.2	93.2

* - INDICATES CLOUD STABILIZATION TIME WAS USED

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----- CLOUD STABILIZATION -----

CALCULATION HEIGHT	(METERS)		0.00
STABILIZATION HEIGHT	(METERS)		811.14
STABILIZATION TIME	(SECS)		214.90
FIRST MIXING LAYER HEIGHT-	(METERS)	TOP =	958.88
		BASE=	0.00
SECOND SELECTED LAYER HEIGHT-	(METERS)	TOP =	3008.96
		BASE=	958.88
SIGMAR(AZ) AT THE SURFACE	(DEGREES)		5.7504
SIGMER(EL) AT THE SURFACE	(DEGREES)		1.0344

MET. LAYER NO.	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIRECTION (DEG)	WIND DIRECTION SHEAR (DEG)	SIGMA OF AZI ANG (DEG)	SIGMA OF ELE ANG (DEG)
1	6.38	1.03	339.00	8.00	5.3966	1.4248
2	6.94	0.51	338.00	-10.00	4.8750	2.2148
3	7.59	0.77	331.25	-3.50	4.2593	3.0144
4	8.36	0.77	327.75	-3.50	4.0129	3.8143
5	8.75	0.00	330.25	8.50	4.5893	4.5893
6	8.75	0.00	338.75	8.50	5.3322	5.3322
7	7.94	1.62	339.75	-6.50	8.8074	8.8074
8	6.31	1.62	333.25	-6.50	16.1653	16.1653
9	5.92	0.82	328.00	-4.00	12.9349	12.9349
10	6.69	0.72	328.00	4.00	10.2701	10.2701
11	7.31	0.51	328.55	-2.90	13.9863	13.9863
12	7.87	0.62	325.33	-3.55	11.6115	11.6115
13	8.49	0.62	321.77	-3.55	9.0613	9.0613
14	8.90	0.21	325.00	10.00	6.5363	6.5363
15	9.18	0.36	325.00	-10.00	4.0918	4.0918
16	9.49	0.26	320.00	0.00	2.2483	2.2483
17	9.72	0.21	321.45	2.90	1.4745	1.4745
18	9.93	0.21	324.35	2.90	1.2243	1.2243
19	11.27	2.47	332.20	12.80	1.0495	1.0495
20	12.53	0.05	339.30	1.40	1.0000	1.0000
21	12.53	-0.05	339.85	-0.30	1.0000	1.0000
22	13.14	1.29	335.75	-7.90	1.0000	1.0000
23	13.97	0.36	331.75	-0.10	1.0000	1.0000
24	14.33	0.36	331.65	-0.10	1.0000	1.0000
25	14.51	0.00	331.65	0.10	1.0000	1.0000
26	14.20	-0.62	330.80	-1.80	1.0000	1.0000
27	13.35	-1.08	327.45	-4.90	1.0000	1.0000
28	12.58	-0.46	324.67	-0.65	1.0000	1.0000
29	12.12	-0.46	324.03	-0.65	1.0000	1.0000
30	11.95	0.13	323.55	-0.30	1.0000	1.0000

----- CALCULATED TRANSITION LAYER PARAMETERS -----

ALTITUDE RANGE USED IN COMPUTING TRANSITION LAYER AVERAGES
IS 0.0 TO 1530.7 METERS.

TRANSITION LAYER NUMBER- 1

VALUE AT	HEIGHT (METERS)	TEMP. (DEG K)	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIR. (DEG)	WIND DIR. SHEAR (DEG)	SIGMA AZI. (DEG)	SIGMA ELE. (DEG)
TOP-	958.88	290.67	12.50		338.60		1.0000	1.0000
LAYER-			8.68	1.46	325.35	6.30	5.5170	5.3877
BOTTOM-	0.00	289.93	5.66		335.00		5.7504	1.0344

TRANSITION LAYER NUMBER- 2

VALUE AT	HEIGHT (METERS)	TEMP. (DEG K)	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIR. (DEG)	WIND DIR. SHEAR (DEG)	SIGMA AZI. (DEG)	SIGMA ELE. (DEG)
TOP-	3008.96	310.38	12.01		323.40		1.0000	1.0000
LAYER-			12.84	0.54	337.60	3.77	1.0000	1.0000
BOTTOM-	958.88	290.67	12.50		338.60		1.0000	1.0000

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----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 0.0 METERS
DOWNWIND FROM A TITAN IV NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 958.9 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	PEAK CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
3000.0110	145.5026	0.2214	2.5994	6.5441
4000.0042	145.2635	1.6879	4.4981	8.6712
5000.1421	144.9154	3.0403	6.3859	10.6111
6000.0645	145.0812	3.7694	8.2640	12.5584
7000.1909	144.9236	4.0888	10.1336	14.5127
8000.3574	144.8054	4.0841	11.9961	16.4733
9000.0645	145.1309	3.8610	13.8526	18.4398
10000.1240	145.0612	3.5287	15.7042	20.4114
11000.1973	145.0042	3.1650	17.5518	22.3876
12000.2783	144.9567	2.8165	19.3960	24.3680
13000.0000	145.3459	2.5017	21.2374	26.3519
14000.0020	145.3134	2.2300	23.0764	28.3390
15000.0088	145.2852	1.9956	24.9136	30.3289
16000.0186	145.2605	1.7935	26.7490	32.3213
17000.0313	145.2388	1.6188	28.5831	34.3158
18000.0449	145.2194	1.4672	30.4160	36.3123
19000.0605	145.2021	1.3350	32.2479	38.3104
20000.0781	145.1865	1.2192	34.0788	40.3101
21000.0977	145.1724	1.1172	35.9091	42.3111
22000.1172	145.1596	1.0271	37.7386	44.3132
23000.1387	145.1479	0.9470	39.5661	46.3164
24000.1602	145.1372	0.8757	41.3926	48.3206
25000.1895	145.5698	0.8104	43.2188	50.3256
26000.1816	145.5612	0.7533	45.0447	52.3314
27000.1758	145.5533	0.7020	46.8704	54.3379
28000.1680	145.5459	0.6555	48.6959	56.3450
29000.1621	145.5391	0.6135	50.5212	58.3527
30000.1582	145.5327	0.5752	52.3463	60.3609
31000.1523	145.5267	0.5404	54.1712	62.3695
32000.1484	145.5211	0.5086	55.9960	64.3786
33000.1445	145.5158	0.4794	57.8207	66.3881
34000.1406	145.5108	0.4527	59.6452	68.3980
35000.1367	145.5061	0.4280	61.4697	70.4082
36000.1328	145.5017	0.4053	63.2940	72.4187
37000.1289	145.4975	0.3844	65.1183	74.4295

----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 0.0 METERS
DOWNWIND FROM A TITAN IV NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 958.9 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	PEAK CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
38000.1250	145.4936	0.3650	66.9424	76.4405
39000.1211	145.4898	0.3470	68.7665	78.4518
40000.1172	145.4863	0.3303	70.5906	80.4633
41000.1133	145.4829	0.3147	72.4145	82.4750
42000.1133	145.4796	0.3003	74.2384	84.4870
43000.1094	145.4765	0.2867	76.0622	86.4991
44000.1055	145.4736	0.2741	77.8860	88.5113
45000.1055	145.4708	0.2623	79.7098	90.5238
46000.1016	145.4681	0.2512	81.5335	92.5363
47000.1016	145.4655	0.2408	83.3571	94.5491
48000.0977	145.4631	0.2310	85.1807	96.5619
49000.0977	145.4607	0.2218	87.0043	98.5749
50000.0938	145.4584	0.2132	88.8278	100.5880
51000.0938	145.4562	0.2050	90.6513	102.6012
52000.0898	145.4541	0.1973	92.4748	104.6145
53000.0898	145.4521	0.1900	94.2982	106.6279
54000.0859	145.4501	0.1831	96.1216	108.6414
55000.0859	145.4483	0.1766	97.9450	110.6550
56000.0859	145.4465	0.1704	99.7684	112.6686
57000.0820	145.4447	0.1645	101.5917	114.6824
58000.0820	145.4431	0.1589	103.4150	116.6962
59000.0781	145.4414	0.1536	105.2383	118.7101
60000.0781	145.4398	0.1486	107.0616	120.7240

	RANGE	BEARING
4.089 IS THE MAXIMUM PEAK CONCENTRATION	7000.2	144.9

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----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 0.0 METERS
DOWNWIND FROM A TITAN IV NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 958.9 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	60.0 MIN. MEAN CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
3000.0110	145.5026	0.0019	2.5994	6.5441
4000.1248	144.8945	0.0233	4.4981	8.6712
5000.1421	144.9154	0.0523	6.3859	10.6111
6000.4028	144.6832	0.0736	8.2640	12.5584
7000.1909	144.9236	0.0871	10.1336	14.5127
8000.3574	144.8054	0.0929	11.9961	16.4733
9000.0645	145.1309	0.0927	13.8526	18.4398
10000.1240	145.0612	0.0891	15.7042	20.4114
11000.1973	145.0042	0.0840	17.5518	22.3876
12000.2783	144.9567	0.0784	19.3960	24.3680
13000.0000	145.3459	0.0730	21.2374	26.3519
14000.0020	145.3134	0.0682	23.0764	28.3390
15000.0088	145.2852	0.0639	24.9136	30.3289
16000.0186	145.2605	0.0601	26.7490	32.3213
17000.0313	145.2388	0.0567	28.5831	34.3158
18000.0449	145.2194	0.0537	30.4160	36.3123
19000.0605	145.2021	0.0510	32.2479	38.3104
20000.0781	145.1865	0.0485	34.0788	40.3101
21000.0977	145.1724	0.0463	35.9091	42.3111
22000.1172	145.1596	0.0442	37.7386	44.3132
23000.1387	145.1479	0.0423	39.5661	46.3164
24000.1602	145.1372	0.0406	41.3926	48.3206
25000.1895	145.5698	0.0390	43.2188	50.3256
26000.1816	145.5612	0.0375	45.0447	52.3314
27000.1758	145.5533	0.0362	46.8704	54.3379
28000.1680	145.5459	0.0349	48.6959	56.3450
29000.1621	145.5391	0.0337	50.5212	58.3527
30000.1582	145.5327	0.0326	52.3463	60.3609
31000.1523	145.5267	0.0316	54.1712	62.3695
32000.1484	145.5211	0.0306	55.9960	64.3786
33000.1445	145.5158	0.0297	57.8207	66.3881
34000.1406	145.5108	0.0289	59.6452	68.3980
35000.1367	145.5061	0.0281	61.4697	70.4082
36000.1328	145.5017	0.0273	63.2940	72.4187

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----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 0.0 METERS
DOWNWIND FROM A TITAN IV NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 958.9 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	60.0 MIN. MEAN CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
37000.1289	145.4975	0.0266	65.1183	74.4295
38000.1250	145.4936	0.0259	66.9424	76.4405
39000.1211	145.4898	0.0252	68.7665	78.4518
40000.1172	145.4863	0.0246	70.5906	80.4633
41000.1133	145.4829	0.0240	72.4145	82.4750
42000.1133	145.4796	0.0235	74.2384	84.4870
43000.1094	145.4765	0.0229	76.0622	86.4991
44000.1055	145.4736	0.0224	77.8860	88.5113
45000.1055	145.4708	0.0219	79.7098	90.5238
46000.1016	145.4681	0.0215	81.5335	92.5363
47000.1016	145.4655	0.0210	83.3571	94.5491
48000.0977	145.4631	0.0206	85.1807	96.5619
49000.0977	145.4607	0.0202	87.0043	98.5749
50000.0938	145.4584	0.0198	88.8278	100.5880
51000.0938	145.4562	0.0194	90.6513	102.6012
52000.0898	145.4541	0.0190	92.4748	104.6145
53000.0898	145.4521	0.0187	94.2982	106.6279
54000.0859	145.4501	0.0183	96.1216	108.6414
55000.0859	145.4483	0.0180	97.9450	110.6550
56000.0859	145.4465	0.0177	99.7684	112.6686
57000.0820	145.4447	0.0174	101.5917	114.6824
58000.0820	145.4431	0.0171	103.4150	116.6962
59000.0781	145.4414	0.0168	105.2383	118.7101
60000.0781	145.4398	0.0165	107.0616	120.7240

	RANGE	BEARING
0.093 IS THE MAXIMUM 60.0 MIN. MEAN CONCENTRATION	8000.4	144.8

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1*****************************************************************************
              ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM        PAGE  12
                          VERSION 7.08 AT VAFB
                          0955 PDT 21 MAY 1998
                     launch time:  1932 PDT 23 OCT 1997
      RAWINSONDE ASCENT NUMBER    231, 0152   Z 24 OCT 1997  T  -0.7 HR
*****************************************************************************

                 ----- hazard box coordinates -----


 HAZARD BOX COORDINATES FOR HCL        CONCENTRATION
        SCENARIO =          NORMAL       MET PROFILE = T  -0.7 HR
        DIRECTIONAL UNCERTAINTY =   25.0  RANGE EXTENSTION FACTOR =    1.3
        SOURCE LOCATION =  34 37 55  120 36 45

 ISOPLETH # 1 VALUE = 4.0888E-01  PPM
 CRASH GRID COORDINATES:
 17 BU   77 AT   78 AA   17 AA   17 BU
 RANGE(NMI) AND BEARING(DEG), LAT(DMS) AND LONG(DMS) :
     12.1  112.      25.1  120.      25.1  145.
     12.1  178.      25.1  171.      25.1  146.
    34 33  1  120 23 21    34 24 44  120 10 51    34 16 54  120 20  2
    34 25 48  120 36 32    34 12 59  120 32 39    34 16 45  120 20 18

 ISOPLETH # 2 VALUE = 1.2267E+00  PPM
 CRASH GRID COORDINATES:
 17 BU   55 BD   77 AL   78 AA   19 AA   18 AF   17 BU
 RANGE(NMI) AND BEARING(DEG), LAT(DMS) AND LONG(DMS) :
      6.9  113.      14.0  120.      14.0  145.
      6.9  177.      14.0  171.      14.0  146.
    34 35  4  120 29 11    34 30 41  120 22 16    34 26 17  120 27 21
    34 31  3  120 36 33    34 24  4  120 34 23    34 26 12  120 27 31

 ISOPLETH # 3 VALUE = 2.0444E+00  PPM
 CRASH GRID COORDINATES:
 17 BU   47 BG   70 AO   57 AA   21 AA   18 AO   17 BU
 RANGE(NMI) AND BEARING(DEG), LAT(DMS) AND LONG(DMS) :
      5.4  114.      10.3  120.      10.3  145.
      5.4  176.      10.3  171.      10.3  146.
    34 35 35  120 30 48    34 32 36  120 26  1    34 29 21  120 29 46
    34 32 29  120 36 27    34 27 40  120 35  6    34 29 13  120 29 59

 ISOPLETH # 4 VALUE = 2.8622E+00  PPM
 CRASH GRID COORDINATES:
 17 BU   43 BH   60 AU   45 AF   44 AE   32 AA   23 AA   19 AR   17 BU
 RANGE(NMI) AND BEARING(DEG), LAT(DMS) AND LONG(DMS) :
      4.9  116.       8.3  119.       8.3  144.
      4.9  175.       8.3  171.       8.3  146.
    34 35 42  120 31 29    34 33 41  120 28  7    34 31  3  120 31  6
    34 33  3  120 36 20    34 29 42  120 35 21    34 30 58  120 31 16
```

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1*****************************************************************************
               ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM        PAGE  13
                           VERSION 7.08 AT VAFB
                           0955 PDT 21 MAY 1998
                    launch time:  1932 PDT 23 OCT 1997
     RAWINSONDE ASCENT NUMBER    231, 0152   Z 24 OCT 1997  T  -0.7 HR
*****************************************************************************

                ----- hazard box coordinates -----

ISOPLETH # 5 VALUE = 3.6800E+00  PPM
CRASH GRID COORDINATES:
17 BU   40 BI   52 AZ   39 AN   39 AM   22 AG   20 AU   17 BU
RANGE(NMI) AND BEARING(DEG), LAT(DMS) AND LONG(DMS) :
     4.3  117.       6.7  120.       6.7  145.
     4.3  172.       6.7  171.       6.7  145.
   34 35 51  120 32  8    34 34 29  120 29 49    34 32 22  120 32 14
   34 33 37  120 36 11    34 31 18  120 35 36    34 32 20  120 32 19

*** REEDM  HAS TERMINATED
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Appendix B—Meteorological Data for the Titan IV A-18 Mission

This appendix contains three types of meteorological data recorded at VAFB before and after the Titan IV A-18 launch, which occurred at 1932 PDT on 23 October 1997 (0232Z on 24 October 1997).

Rawinsonde Data

This data file was provided by a rawinsonde balloon launched at 0152Z (T–40 min) from Building 1764 on north VAFB. This rawinsonde file was used as the meteorological input for the REEDM runs displayed in Appendix A.

Tower Data

These datasets were taken at a series of meteorological towers located on north and south VAFB. They represent 10-min averages beginning at 0220Z and ending at 0250Z. Data are taken at height in meters above sea level (HMSL) and represent speed in knots, wind direction is degrees azimuth, and temperature in °F. The location of the towers in latitude north and longitude west are:

Tower 4	34 31 51	120 33 55
Tower 5	34 45 13	120 34 16
Tower 7	34 43 57	120 32 01
Tower 8	34 49 32	120 30 30
Tower 14	34 36 31	120 31 31
Tower 15	34 46 16	120 31 51
Tower 17	34 52 56	120 38 12
Tower 18	34 50 42	120 34 57
Tower 20	34 36 27	120 27 52
Tower 50	34 48 02	120 35 55
Tower 51	34 42 36	120 33 55
Tower 52	34 44 09	120 35 43
Tower 53	34 33 24	120 36 42
Tower 54	34 38 31	120 35 28
Tower 55	34 35 14	120 35 39
Tower 56	34 34 59	120 33 40
Tower 57	34 40 01	120 35 21
Tower 58	34 41 50	120 32 17
Tower 59	34 48 08	120 34 52
Tower 60	34 50 59	120 35 57
Tower 61	34 38 33	120 33 21
Tower 64	34 36 50	120 33 03
Tower 65	34 33 59	120 29 59

Tower 66	34 39 54	120 33 17
Tower 101	34 36 38	120 33 58
Tower 102	34 45 30	120 37 18
Tower 200	34 36 28	120 37 35
Tower 300	34 38 01	120 36 50
Tower 301	34 34 48	120 37 57

Doppler Acoustic Sounder System (DASS) Data

These datasets were taken from four DASS units on north and south VAFB. They represent 10-min averages beginning at 0230Z and ending at 0250Z. The four DASS units were located at Building 1764 (DAS1), Building 900 (DAS2), SLC-4 (DAS3), and LF-03 (DAS4).

Tower 300 and Rawinsonde Data

$ 10/24/97 02:56:37

0220Z 10 24 97 10

TWR	LVL	HMSL	SPD	DIR	TEMP	RH	TD	SOSD	SOSM	PRESS	SIG-A	SIG-E
300	1	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	7.1	1.0
300	54	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	6.2	1.8
300	102	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	5.8	2.6
300	204	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	3.6	4.2
300	300	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	2.2	5.7
300	492	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	2.1	20.5
300	656	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	2.1	5.4
300	820	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	2.0	15.1
300	965	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.9	12.9
300	1312	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.8	7.8
300	1476	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.7	5.3
300	1640	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.6	2.9
300	2043	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.5	1.6
300	3056	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.0	1.1
300	3145	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.0	1.0
300	3294	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.0	1.0
300	4033	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.0	1.0
300	5021	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.0	1.0
300	6118	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.0	1.0
300	7081	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.0	1.0
300	7508	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.0	1.0
300	7737	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.0	1.0
300	9320	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.0	1.0
300	10422	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	999.0	1.0	1.0

$ 10/24/97 02:56:56

UNINTERPOLATED DATA

TEST NBR SITE: 1764 OP NO: W0444 ASC NO: 231

1764

BLDG 1764, VANDENBERG AFB, CALIF.

RAWINSONDE MSS/WIN 12.0 8.4 24

0152Z 24 OCT 1997 894.11 10 762

ASCENT NBR 231

ALT	DIR	SPD	TEMP	DEWPT	PRESS	RH	ABH	DENSITY	IR	SOS	S	I
329.0	335.0	11.0	15.5	11.7	1002.70	78.0	0.0	1210.15	0.0	0.0	1	9
383.0	343.0	13.0	15.3	11.7	1000.75	78.8	0.0	1208.15	0.0	0.0	1	0
431.0	333.0	14.0	15.2	11.6	999.03	79.5	0.0	1206.38	0.0	0.0	1	0
533.0	326.0	17.0	14.9	11.6	995.36	81.0	0.0	1202.63	0.0	0.0	1	0
629.0	343.0	17.0	14.6	11.5	991.93	82.4	0.0	1199.10	0.0	0.0	1	0
821.0	330.0	10.7	14.0	11.4	985.10	85.1	0.0	1192.08	0.0	0.0	2	0
985.0	326.0	12.3	13.5	11.4	979.30	87.5	0.0	1186.12	0.0	0.0	2	0
1149.0	330.0	13.7	13.0	11.3	973.53	89.9	0.0	1180.19	0.0	0.0	2	0
1294.0	327.1	14.7	12.5	11.2	968.46	92.0	0.0	1174.97	0.0	0.0	2	9
1641.0	320.0	17.1	11.7	10.6	956.31	93.5	0.0	1163.80	0.0	0.0	2	0
1805.0	330.0	17.5	11.3	10.3	950.62	94.2	0.0	1158.56	0.0	0.0	2	0
1969.0	320.0	18.2	10.9	10.1	944.96	94.9	0.0	1153.34	0.0	0.0	2	0
2372.0	320.0	18.7	9.9	9.4	931.20	96.6	0.0	1140.62	0.0	0.0	2	9
3385.0	325.8	19.5	7.3	6.7	897.19	96.0	0.0	1109.88	0.0	0.0	4	9
3474.0	338.6	24.3	7.6	-.4	894.27	57.0	0.0	1106.89	0.0	0.0	4	9
3623.0	340.0	24.4	12.8	0.2	889.40	42.0	0.0	1080.71	0.0	0.0	4	9
4362.0	339.7	24.3	13.6	-3.9	865.91	29.4	0.0	1049.91	0.0	0.0	4	9
5350.0	331.8	26.8	13.0	-6.9	835.50	24.3	0.0	1015.51	0.0	0.0	4	9
6447.0	331.6	28.2	10.7	-7.5	802.79	27.1	0.0	983.67	0.0	0.0	4	9

7410.0	331.7	28.2	8.4	-8.4	774.91	29.4	0.0	957.33	0.0	0.0	4	9
7837.0	329.9	27.0	7.6	-8.8	762.81	30.0	0.0	945.09	0.0	0.0	4	9
8066.0	325.0	24.9	9.2	-12.0	756.41	21.0	0.0	932.15	0.0	0.0	4	9
9649.0	323.7	23.1	7.5	-13.3	713.55	21.2	0.0	884.72	0.0	0.0	4	0
10751.0	323.1	23.6	5.5	-15.1	684.98	20.9	0.0	855.50	0.0	0.0	4	9

--=====================_878633398==_--

Tower and DASS Data

0220Z 24 10 97 10

TWR	LVL	HMSL	SPD	DIR	TEMP	RH	TD	SOSD	SOSM	PRESS	SIGMA
004	012	407.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
005	012	342.0	8.0	329.0	999.0	999.0	999.0	999.0	999.0	9999.0	13.8
007	012	456.0	6.0	310.0	999.0	999.0	999.0	999.0	999.0	9999.0	13.8
008	012	932.0	8.0	295.0	13.9	999.0	999.0	659.9	999.0	9999.0	7.6
014	012	1458.0	17.0	338.0	999.0	999.0	999.0	999.0	999.0	9999.0	4.8
015	012	584.0	7.0	335.0	999.0	999.0	999.0	999.0	999.0	9999.0	11.6
017	012	137.0	9.0	307.0	999.0	999.0	999.0	999.0	999.0	9999.0	7.4
018	012	312.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
020	012	321.0	4.0	337.0	15.6	999.0	999.0	661.8	999.0	9999.0	26.0
050	012	147.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
050	054	189.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
051	012	412.0	7.0	314.0	15.6	999.0	999.0	661.8	999.0	9999.0	8.9
051	054	454.0	10.0	318.0	15.3	999.0	999.0	661.6	999.0	9999.0	9.1
052	012	302.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
052	054	344.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
053	012	102.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
053	054	144.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
054	012	462.0	10.0	317.0	15.6	999.0	999.0	661.8	999.0	9999.0	7.7
054	054	504.0	12.0	318.0	15.6	999.0	999.0	661.8	999.0	9999.0	7.2
055	040	1570.0	29.0	315.0	12.1	999.0	999.0	657.8	999.0	9999.0	3.5
056	040	2176.0	11.0	270.0	10.6	999.0	999.0	656.1	999.0	9999.0	38.2
057	012	308.0	5.0	309.0	16.1	999.0	999.0	662.4	999.0	9999.0	21.0
057	054	350.0	6.0	314.0	16.0	999.0	999.0	662.3	999.0	9999.0	16.9
058	012	387.0	9.0	337.0	15.6	68.0	8.9	661.8	663.6	9999.0	6.2
058	054	429.0	.0	.0	999.0	999.0	999.0	999.0	999.0	9999.0	.0
059	012	238.0	8.0	310.0	15.6	75.0	10.6	661.8	663.8	1006.1	11.3
059	054	280.0	11.0	318.0	15.7	79.5	11.7	661.9	664.0	9999.0	5.9
060	012	133.0	8.0	311.0	16.1	68.1	9.4	662.4	664.3	1008.0	6.6
060	054	175.0	10.0	307.0	16.0	64.1	8.3	662.3	664.1	9999.0	4.6
061	012	516.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
061	054	558.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
064	012	1212.0	12.0	350.0	12.8	999.0	999.0	658.6	999.0	9999.0	8.1
064	054	1254.0	15.0	343.0	12.8	999.0	999.0	658.6	999.0	9999.0	8.6
065	012	2065.0	16.0	213.0	10.6	999.0	999.0	656.1	999.0	9999.0	41.0
065	054	2107.0	1.0	330.0	10.2	999.0	999.0	655.7	999.0	9999.0	7.4
066	012	39.0	9.0	311.0	16.1	75.1	11.1	662.4	664.4	9999.0	7.9
066	054	81.0	11.0	313.0	16.0	999.0	999.0	662.3	999.0	9999.0	7.4
101	012	1089.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
101	054	1131.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
102	012	227.0	11.0	320.0	16.1	999.0	999.0	662.4	999.0	9999.0	5.6
102	054	269.0	13.0	316.0	15.9	999.0	999.0	662.2	999.0	9999.0	4.8
102	102	317.0	14.0	315.0	999.0	999.0	999.0	999.0	999.0	9999.0	4.9
200	012	322.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
200	054	364.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
200	102	412.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
200	204	514.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
300	012	397.0	11.0	335.0	15.0	999.0	999.0	661.2	999.0	9999.0	7.1
300	054	439.0	13.0	343.0	14.6	999.0	999.0	660.7	999.0	9999.0	6.2
300	102	487.0	14.0	333.0	14.8	999.0	999.0	661.0	999.0	9999.0	5.8
300	108	493.0	15.0	336.0	999.0	999.0	999.0	999.0	999.0	9999.0	6.6
300	204	589.0	17.0	326.0	14.6	999.0	999.0	660.7	999.0	9999.0	3.6
300	300	685.0	17.0	343.0	14.4	999.0	999.0	660.5	999.0	9999.0	2.2

301	012	392.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	054	434.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	102	482.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	204	584.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	300	680.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0

DASS DATA FROM BLDG. DAS1, UNEDITED

24/10/97 02:30 10-MIN. AVE.

ALT M	DIR DEG	V KNOTS	VZ KNOTS	SD DEG	SV KNOTS	SZ KNOTS
GND	269	4.3	.6	.4	1.2	.6
50	48	3.7	.2	13.5	.6	.6
100	35	1.0	-.6	45.1	.8	.4
150	313	17.1	-.6	3.1	.6	.6
200	313	17.9	-.8	2.9	.6	.6
250	314	17.7	-.8	3.1	.6	.6
300	315	17.9	-.8	3.2	.8	.6
350	316	18.1	-.8	3.3	.8	.8
400	317	18.1	-.8	3.4	.8	.6
450	319	17.9	-.6	3.0	.6	.6
500	317	17.5	-.8	3.2	.8	.6
550	319	16.7	-.6	3.5	.8	.6
600	319	16.7	-.8	3.5	.8	.6
650	318	16.7	-1.0	3.3	.6	.4
700	320	16.5	-1.0	3.4	.8	.6
750	319	15.9	-1.2	3.3	.6	.8
800	323	15.9	-1.0	3.8	.8	.6
850	328	17.1	-1.0	3.1	.6	.6
900	330	19.4	-.8	3.1	.8	.6
950	332	22.0	-.6	2.9	1.0	.8
1000	335	24.9	-.4	2.9	1.2	1.6

DASS DATA FROM BLDG. DAS2, UNEDITED

24/10/97 02:20 10-MIN. AVE.

ALT M	DIR DEG	V KNOTS	VZ KNOTS	SD DEG	SV KNOTS	SZ KNOTS
GND	311	9.1	.8	4.3	1.7	.6
50	--	--	.0	--	--	1.6
100	--	--	-15.7	--	--	--
150	--	--	--	--	--	--
200	--	--	4.1	--	--	.2
250	--	--	4.1	--	--	--
300	--	--	4.5	--	--	.6
350	--	--	5.2	--	--	1.2
400	--	--	3.3	--	--	.6
450	--	--	--	--	--	--
500	--	--	2.9	--	--	1.0
550	--	--	4.3	--	--	--
600	--	--	2.5	--	--	--
650	--	--	2.7	--	--	.4
700	263	10.3	3.3	--	--	1.0
750	--	--	3.9	--	--	.4
800	--	--	2.5	--	--	1.0
850	--	--	3.5	--	--	1.2
900	40	10.1	3.9	--	--	1.9
950	66	10.9	4.3	--	--	--
1000	--	--	3.7	--	--	1.6

DASS DATA FROM BLDG. DAS3, UNEDITED

24/10/97 02:30 10-MIN. AVE.

ALT M	DIR DEG	V KNOTS	VZ KNOTS	SD DEG	SV KNOTS	SZ KNOTS
GND	318	8.9	.2	.8	.8	.6
50	6	1.4	.8	37.6	2.9	1.7
100	336	5.4	.2	43.4	4.1	.6
150	275	2.7	.2	50.3	3.5	1.0
200	326	10.3	-.2	88.2	5.6	1.0
250	102	3.7	.2	87.0	4.3	1.0
300	--	--	.6	--	--	1.0
350	--	--	.6	--	--	1.4
400	255	4.1	-1.9	--	--	--
450	357	2.5	1.9	--	--	1.7
500	52	19.2	2.9	75.2	7.8	1.0
550	149	31.7	2.5	--	--	.4
600	--	--	1.0	--	--	1.2
650	138	22.7	2.5	--	--	.8
700	--	--	2.3	--	--	.4
750	--	--	1.2	--	--	.6
800	--	--	--	--	--	--
850	--	--	1.7	--	--	1.4
900	--	--	1.9	--	--	--
950	--	--	1.6	--	--	--
1000	--	--	1.2	--	--	.0

DASS DATA FROM BLDG. DAS4, UNEDITED

24/10/97 02:20 10-MIN. AVE.

ALT M	DIR DEG	V KNOTS	VZ KNOTS	SD DEG	SV KNOTS	SZ KNOTS
GND	308	2.5	--	2.2	.2	--
50	310	9.3	-.8	5.1	.8	.6
100	305	9.7	-1.2	6.5	1.0	.4
150	304	13.0	-1.2	4.0	.6	.6
200	305	12.4	-1.4	4.6	.8	.8
250	308	11.3	-1.6	5.4	.8	1.0
300	312	10.5	-1.7	6.1	1.0	1.0
350	310	11.5	-1.6	5.0	.8	1.0
400	312	10.1	-1.9	5.2	.6	1.0
450	314	11.5	-1.6	5.3	.8	.8
500	313	7.2	-2.1	8.8	1.0	1.4
550	315	6.4	-2.5	8.7	.8	1.6
600	--	--	--	--	--	--
650	--	--	--	--	--	--
700	308	7.4	-2.3	8.9	1.0	1.4
750	319	5.8	-2.5	10.7	.8	1.4
800	--	--	--	--	--	--
850	--	--	--	--	--	--
900	--	--	--	--	--	--
950	333	19.2	-1.0	3.3	1.0	1.0
1000	341	18.1	-1.4	4.2	1.2	1.0

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TWR	LVL	HMSL	SPD	DIR	TEMP	RH	TD	SOSD	SOSM	PRESS	SIGMA
004	012	407.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
005	012	342.0	8.0	323.0	999.0	999.0	999.0	999.0	999.0	9999.0	10.8
007	012	456.0	6.0	312.0	999.0	999.0	999.0	999.0	999.0	9999.0	10.8

008	012	932.0	7.0	293.0	13.3	999.0	999.0	659.3	999.0	9999.0	9.0
014	012	1458.0	18.0	338.0	999.0	999.0	999.0	999.0	999.0	9999.0	5.7
015	012	584.0	7.0	333.0	999.0	999.0	999.0	999.0	999.0	9999.0	22.2
017	012	137.0	9.0	313.0	999.0	999.0	999.0	999.0	999.0	9999.0	7.1
018	012	312.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
020	012	321.0	7.0	337.0	15.6	999.0	999.0	661.8	999.0	9999.0	17.1
050	012	147.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
050	054	189.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
051	012	412.0	7.0	317.0	15.6	999.0	999.0	661.8	999.0	9999.0	13.1
051	054	454.0	10.0	319.0	15.3	999.0	999.0	661.6	999.0	9999.0	10.5
052	012	302.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
052	054	344.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
053	012	102.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
053	054	144.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
054	012	462.0	10.0	317.0	15.6	999.0	999.0	661.8	999.0	9999.0	8.8
054	054	504.0	11.0	319.0	15.6	999.0	999.0	661.8	999.0	9999.0	5.3
055	040	1570.0	29.0	314.0	12.1	999.0	999.0	657.8	999.0	9999.0	4.8
056	040	2176.0	12.0	136.0	10.6	999.0	999.0	656.1	999.0	9999.0	48.0
057	012	308.0	6.0	302.0	16.1	999.0	999.0	662.4	999.0	9999.0	14.9
057	054	350.0	8.0	314.0	16.1	999.0	999.0	662.4	999.0	9999.0	30.6
058	012	387.0	8.0	318.0	15.6	68.0	8.9	661.8	663.6	9999.0	7.0
058	054	429.0	.0	.0	999.0	999.0	999.0	999.0	999.0	9999.0	.0
059	012	238.0	8.0	306.0	15.6	75.0	10.6	661.8	663.8	1006.1	9.1
059	054	280.0	10.0	314.0	15.6	79.8	11.7	661.9	663.9	9999.0	6.4
060	012	133.0	9.0	310.0	16.1	68.1	9.4	662.4	664.3	1008.1	7.6
060	054	175.0	11.0	306.0	16.0	64.1	8.3	662.3	664.1	9999.0	5.8
061	012	516.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
061	054	558.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
064	012	1212.0	13.0	349.0	12.8	999.0	999.0	658.6	999.0	9999.0	10.4
064	054	1254.0	16.0	341.0	12.8	999.0	999.0	658.6	999.0	9999.0	10.6
065	012	2065.0	14.0	216.0	11.1	999.0	999.0	656.7	999.0	9999.0	75.1
065	054	2107.0	1.0	329.0	10.7	999.0	999.0	656.2	999.0	9999.0	6.0
066	012	39.0	10.0	313.0	16.1	75.1	11.1	662.4	664.4	9999.0	7.0
066	054	81.0	11.0	315.0	16.0	999.0	999.0	662.3	999.0	9999.0	5.4
101	012	1089.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
101	054	1131.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
102	012	227.0	12.0	322.0	16.1	999.0	999.0	662.4	999.0	9999.0	6.0
102	054	269.0	14.0	319.0	15.9	999.0	999.0	662.2	999.0	9999.0	5.4
102	102	317.0	15.0	319.0	999.0	999.0	999.0	999.0	999.0	9999.0	3.6
200	012	322.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
200	054	364.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
200	102	412.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
200	204	514.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
300	012	397.0	10.0	343.0	15.0	999.0	999.0	661.2	999.0	9999.0	7.8
300	054	439.0	12.0	350.0	14.6	999.0	999.0	660.7	999.0	9999.0	6.4
300	102	487.0	13.0	340.0	14.8	999.0	999.0	661.0	999.0	9999.0	5.0
300	108	493.0	13.0	343.0	999.0	999.0	999.0	999.0	999.0	9999.0	5.1
300	204	589.0	14.0	334.0	14.6	999.0	999.0	660.7	999.0	9999.0	2.9
300	300	685.0	15.0	351.0	14.3	999.0	999.0	660.4	999.0	9999.0	2.7
301	012	392.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	054	434.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	102	482.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	204	584.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	300	680.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0

DASS DATA FROM BLDG. DAS1, UNEDITED

24/10/97 02:40 10-MIN. AVE.

ALT	DIR	V	VZ	SD	SV	SZ
M	DEG	KNOTS	KNOTS	DEG	KNOTS	KNOTS
GND	269	4.9	.4	.3	1.4	.4
50	41	2.7	--	15.7	.8	.6
100	34	.8	-.8	53.1	.8	.4
150	313	16.5	-.6	3.4	.8	.4
200	314	17.7	-.6	3.1	.6	.6
250	313	17.7	-.8	3.2	.8	.6
300	314	18.1	-.8	2.9	.6	.4
350	317	18.1	-.6	2.9	.6	.4
400	318	18.1	-.4	3.2	.8	.6
450	318	18.1	-.4	3.2	.8	.4
500	315	17.7	-1.0	3.4	.8	.6
550	314	17.5	-1.4	3.0	.6	1.2
600	324	16.9	-.4	3.2	.6	1.4
650	315	16.3	-1.4	3.4	.8	.4
700	318	16.1	-1.2	3.5	.8	.8
750	321	16.5	-1.2	3.6	.8	.6
800	324	16.1	-1.2	4.0	1.0	.6
850	328	17.5	-1.0	3.4	.8	.6
900	327	19.2	-1.2	2.9	.6	.6
950	327	21.4	-1.4	2.8	.8	.8
1000	326	23.7	-1.6	3.1	1.2	1.0

DASS DATA FROM BLDG. DAS2, UNEDITED

24/10/97 02:30 10-MIN. AVE.

ALT	DIR	V	VZ	SD	SV	SZ
M	DEG	KNOTS	KNOTS	DEG	KNOTS	KNOTS
GND	314	8.7	1.0	3.3	1.2	.6
50	--	--	.4	--	--	1.6
100	--	--	2.3	--	--	.2
150	--	--	--	--	--	--
200	--	--	4.1	--	--	--
250	--	--	4.1	--	--	--
300	--	--	--	--	--	--
350	--	--	2.9	--	--	--
400	--	--	4.9	--	--	--
450	--	--	5.2	--	--	.8
500	--	--	4.1	--	--	1.0
550	--	--	3.7	--	--	1.0
600	--	--	4.9	--	--	1.0
650	--	--	--	--	--	--
700	--	--	4.3	--	--	.8
750	--	--	3.5	--	--	1.6
800	--	--	4.3	--	--	.0
850	--	--	3.1	--	--	--
900	--	--	3.5	--	--	.4
950	--	--	3.3	--	--	.2
1000	--	--	4.3	--	--	1.0

DASS DATA FROM BLDG. DAS3, UNEDITED

24/10/97 02:40 10-MIN. AVE.

ALT	DIR	V	VZ	SD	SV	SZ
M	DEG	KNOTS	KNOTS	DEG	KNOTS	KNOTS
GND	318	9.3	.4	.4	.6	.6
50	353	1.9	.6	27.1	3.3	1.6
100	342	6.6	1.0	39.5	5.2	1.4

150	351	3.5	.6	71.8	3.3	1.0
200	42	7.0	.8	64.3	3.7	1.4
250	63	2.3	.6	74.3	3.1	1.6
300	64	16.7	.4	53.3	2.7	.6
350	124	8.4	1.7	57.7	3.7	1.6
400	152	18.7	.8	--	--	.2
450	129	6.0	1.9	--	--	.6
500	209	9.3	2.7	--	--	.8
550	--	--	1.4	--	--	--
600	--	--	1.7	--	--	1.6
650	--	--	1.7	--	--	1.4
700	--	--	1.9	--	--	.2
750	226	23.1	2.1	--	--	.4
800	--	--	--	--	--	2.1
850	118	20.8	-1.9	--	--	--
900	--	--	3.5	--	--	2.5
950	--	--	1.4	--	--	2.1
1000	--	--	-16.7	--	--	--

DASS DATA FROM BLDG. DAS4, UNEDITED

24/10/97 02:30 10-MIN. AVE.

ALT M	DIR DEG	V KNOTS	VZ KNOTS	SD DEG	SV KNOTS	SZ KNOTS
GND	308	2.7	--	3.4	--	--
50	314	6.8	-1.0	5.3	.6	.8
100	302	8.2	-1.4	6.9	.8	.4
150	311	10.7	-1.2	4.9	.6	1.0
200	316	11.5	-1.0	4.6	.6	.8
250	311	10.7	-1.2	4.9	.6	.8
300	305	11.7	-1.2	4.5	.6	.6
350	284	6.0	-2.1	9.8	.8	1.2
400	298	6.8	-1.9	7.7	.6	1.4
450	305	8.0	-1.7	6.6	.6	1.4
500	308	14.6	-.8	3.6	.6	.4
550	305	10.3	-1.6	5.1	.6	.8
600	--	--	--	--	--	--
650	--	--	--	--	--	--
700	--	--	--	--	--	--
750	298	14.2	-1.0	4.9	1.2	.4
800	298	10.3	-1.9	6.2	1.0	1.4
850	306	9.9	-1.9	6.5	1.0	1.4
900	316	15.0	-1.4	4.5	1.0	1.0
950	322	17.9	-1.0	3.6	1.0	1.0
1000	330	16.5	-1.6	4.1	1.0	1.4

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TWR	LVL	HMSL	SPD	DIR	TEMP	RH	TD	SOSD	SOSM	PRESS	SIGMA
004	012	407.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
005	012	342.0	8.0	321.0	999.0	999.0	999.0	999.0	999.0	9999.0	11.6
007	012	456.0	6.0	311.0	999.0	999.0	999.0	999.0	999.0	9999.0	8.9
008	012	932.0	7.0	296.0	13.9	999.0	999.0	659.9	999.0	9999.0	7.6
014	012	1458.0	17.0	334.0	999.0	999.0	999.0	999.0	999.0	9999.0	5.8
015	012	584.0	7.0	334.0	999.0	999.0	999.0	999.0	999.0	9999.0	10.9
017	012	137.0	9.0	314.0	999.0	999.0	999.0	999.0	999.0	9999.0	10.1
018	012	312.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
020	012	321.0	7.0	342.0	15.6	999.0	999.0	661.8	999.0	9999.0	18.3
050	012	147.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
050	054	189.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0

051	012	412.0	8.0	308.0	15.6	999.0	999.0	661.8	999.0	9999.0	12.5
051	054	454.0	10.0	314.0	15.4	999.0	999.0	661.6	999.0	9999.0	9.2
052	012	302.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
052	054	344.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
053	012	102.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
053	054	144.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
054	012	462.0	10.0	322.0	15.0	999.0	999.0	661.2	999.0	9999.0	6.9
054	054	504.0	11.0	322.0	15.0	999.0	999.0	661.2	999.0	9999.0	7.2
055	040	1570.0	26.0	316.0	12.0	999.0	999.0	657.7	999.0	9999.0	6.7
056	040	2176.0	11.0	6.0	10.6	999.0	999.0	656.1	999.0	9999.0	40.5
057	012	308.0	5.0	323.0	15.6	999.0	999.0	661.8	999.0	9999.0	15.3
057	054	350.0	6.0	329.0	15.5	999.0	999.0	661.7	999.0	9999.0	17.6
058	012	387.0	9.0	316.0	15.6	68.0	8.9	661.8	663.6	9999.0	5.5
058	054	429.0	.0	.0	999.0	999.0	999.0	999.0	999.0	9999.0	.0
059	012	238.0	8.0	305.0	15.6	72.6	10.0	661.8	663.7	1006.1	9.0
059	054	280.0	11.0	312.0	15.6	77.2	11.1	661.9	663.9	9999.0	6.9
060	012	133.0	7.0	312.0	16.1	68.1	9.4	662.4	664.3	1008.1	8.5
060	054	175.0	9.0	308.0	16.0	64.1	8.3	662.3	664.1	9999.0	5.4
061	012	516.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
061	054	558.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
064	012	1212.0	12.0	349.0	12.8	999.0	999.0	658.6	999.0	9999.0	8.8
064	054	1254.0	14.0	344.0	12.8	999.0	999.0	658.6	999.0	9999.0	9.3
065	012	2065.0	16.0	216.0	10.6	999.0	999.0	656.1	999.0	9999.0	63.7
065	054	2107.0	1.0	327.0	10.2	999.0	999.0	655.6	999.0	9999.0	7.4
066	012	39.0	10.0	305.0	16.1	72.7	10.6	662.4	664.4	9999.0	8.8
066	054	81.0	12.0	308.0	16.1	999.0	999.0	662.4	999.0	9999.0	5.9
101	012	1089.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
101	054	1131.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
102	012	227.0	10.0	326.0	16.1	999.0	999.0	662.4	999.0	9999.0	7.3
102	054	269.0	13.0	323.0	15.9	999.0	999.0	662.2	999.0	9999.0	4.4
102	102	317.0	14.0	322.0	999.0	999.0	999.0	999.0	999.0	9999.0	2.5
200	012	322.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
200	054	364.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
200	102	412.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
200	204	514.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
300	012	397.0	10.0	342.0	15.0	999.0	999.0	661.2	999.0	9999.0	6.4
300	054	439.0	12.0	348.0	14.6	999.0	999.0	660.7	999.0	9999.0	6.9
300	102	487.0	13.0	292.0	14.8	999.0	999.0	660.9	999.0	9999.0	7.0
300	108	493.0	13.0	342.0	999.0	999.0	999.0	999.0	999.0	9999.0	6.6
300	204	589.0	14.0	334.0	14.6	999.0	999.0	660.7	999.0	9999.0	5.5
300	300	685.0	14.0	350.0	14.3	999.0	999.0	660.3	999.0	9999.0	4.7
301	012	392.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	054	434.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	102	482.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	204	584.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	300	680.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0

DASS DATA FROM BLDG. DAS1, UNEDITED

24/10/97 02:50 10-MIN. AVE.

ALT	DIR	V	VZ	SD	SV	SZ
M	DEG	KNOTS	KNOTS	DEG	KNOTS	KNOTS
GND	269	4.9	.4	.3	1.4	.4
50	--	--	--	--	--	--
100	--	--	--	--	--	--
150	315	16.5	-.6	3.2	.6	.4
200	315	16.7	-.8	3.2	.6	.4
250	315	16.5	-1.0	3.2	.6	.6

300	314	16.5	-1.0	3.2	.6	.6
350	316	16.9	-1.0	3.1	.6	.6
400	316	17.1	-1.2	3.1	.6	.8
450	318	16.7	-1.0	3.2	.6	.8
500	319	16.9	-1.2	3.3	.6	.8
550	319	16.9	-1.4	3.1	.6	.8
600	323	17.5	-.8	3.4	.8	.6
650	323	16.9	-1.4	4.0	1.0	.6
700	318	16.5	-1.7	3.4	.8	1.0
750	321	15.9	-1.6	3.9	.8	.8
800	324	16.5	-1.6	4.2	1.0	.6
850	321	16.7	-1.7	3.6	.8	.8
900	322	19.0	-1.4	3.1	.8	.6
950	321	21.6	-1.4	2.8	.8	.6
1000	323	23.9	-1.2	2.8	1.0	.8

DASS DATA FROM BLDG. DAS2, UNEDITED

24/10/97 02:40 10-MIN. AVE.

ALT	DIR	V	VZ	SD	SV	SZ
M	DEG	KNOTS	KNOTS	DEG	KNOTS	KNOTS
GND	323	8.0	.8	4.8	1.2	.6
50	26	1.9	.2	--	--	1.4
100	--	--	3.5	--	--	.6
150	88	8.2	3.3	--	--	2.1
200	--	--	4.3	--	--	--
250	--	--	--	--	--	--
300	--	--	2.9	--	--	--
350	--	--	4.7	--	--	1.0
400	--	--	4.7	--	--	.6
450	--	--	--	--	--	--
500	--	--	--	--	--	--
550	--	--	3.1	--	--	--
600	--	--	3.9	--	--	1.0
650	--	--	4.7	--	--	1.6
700	--	--	--	--	--	--
750	--	--	5.2	--	--	--
800	--	--	2.9	--	--	--
850	--	--	3.7	--	--	.4
900	--	--	--	--	--	--
950	--	--	2.5	--	--	--
1000	--	--	4.1	--	--	--

DASS DATA FROM BLDG. DAS3, UNEDITED

24/10/97 02:50 10-MIN. AVE.

ALT	DIR	V	VZ	SD	SV	SZ
M	DEG	KNOTS	KNOTS	DEG	KNOTS	KNOTS
GND	318	9.1	.2	.6	1.0	.8
50	351	5.8	.8	32.5	7.2	1.7
100	30	9.1	1.2	72.5	5.4	2.1
150	35	7.4	1.7	41.1	3.3	2.1
200	340	11.3	.8	70.4	6.8	1.2
250	35	9.7	.4	116.0	5.2	1.2
300	113	22.7	.6	--	--	1.0
350	2	14.2	.4	--	--	.6
400	95	20.2	3.7	60.4	4.7	.6
450	280	37.1	3.3	35.6	20.0	2.5
500	254	24.9	--	15.1	6.6	--

550	264	31.7	4.9	--	--	2.7
600	332	48.4	3.3	--	--	2.9
650	319	58.9	1.4	--	--	2.5
700	328	57.5	2.3	--	--	1.4
750	271	62.0	1.7	--	--	--
800	339	56.0	1.9	--	--	--
850	262	55.0	--	--	--	--
900	269	58.1	1.9	--	--	--
950	208	13.4	1.0	--	--	.6
1000	--	--	.8	--	--	1.4

DASS DATA FROM BLDG. DAS4, UNEDITED

24/10/97 02:40 10-MIN. AVE.

ALT M	DIR DEG	V KNOTS	VZ KNOTS	SD DEG	SV KNOTS	SZ KNOTS
GND	311	2.3	--	3.7	.2	--
50	318	7.8	-.8	5.1	.6	.6
100	312	9.9	-1.2	6.0	.8	.4
150	317	10.5	-1.4	5.0	.6	.4
200	322	10.9	-1.4	4.8	.6	.6
250	323	12.1	-1.2	4.4	.6	.8
300	324	10.7	-1.4	4.9	.6	1.0
350	317	10.9	-1.4	4.8	.6	1.2
400	314	11.7	-1.2	4.5	.6	1.0
450	306	7.8	-1.9	6.7	.6	1.2
500	204	1.4	-3.1	36.7	.8	1.9
550	--	--	--	--	--	--
600	--	--	--	--	--	--
650	--	--	--	--	--	--
700	219	3.1	-3.5	22.2	1.2	1.6
750	--	--	--	--	--	--
800	--	--	--	--	--	--
850	306	14.4	-1.2	4.4	1.0	.8
900	313	15.4	-1.4	3.5	.6	1.2
950	317	16.1	-1.4	3.3	.6	1.2
1000	--	--	--	--	--	--

0250Z 24 10 97 10

TWR	LVL	HMSL	SPD	DIR	TEMP	RH	TD	SOSD	SOSM	PRESS	SIGMA
004	012	407.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
005	012	342.0	8.0	319.0	999.0	999.0	999.0	999.0	999.0	9999.0	8.1
007	012	456.0	5.0	312.0	999.0	999.0	999.0	999.0	999.0	9999.0	12.7
008	012	932.0	6.0	297.0	13.9	999.0	999.0	659.9	999.0	9999.0	6.5
014	012	1458.0	16.0	338.0	999.0	999.0	999.0	999.0	999.0	9999.0	5.5
015	012	584.0	7.0	332.0	999.0	999.0	999.0	999.0	999.0	9999.0	9.3
017	012	137.0	9.0	314.0	999.0	999.0	999.0	999.0	999.0	9999.0	9.6
018	012	312.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
020	012	321.0	7.0	339.0	15.0	999.0	999.0	661.2	999.0	9999.0	22.8
050	012	147.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
050	054	189.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
051	012	412.0	7.0	316.0	15.6	999.0	999.0	661.8	999.0	9999.0	6.0
051	054	454.0	10.0	320.0	15.3	999.0	999.0	661.6	999.0	9999.0	9.6
052	012	302.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
052	054	344.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
053	012	102.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
053	054	144.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
054	012	462.0	10.0	318.0	15.0	999.0	999.0	661.2	999.0	9999.0	8.5
054	054	504.0	12.0	319.0	15.0	999.0	999.0	661.2	999.0	9999.0	5.8

055	040	1570.0	26.0	315.0	12.1	999.0	999.0	657.8	999.0	9999.0	4.4
056	040	2176.0	11.0	283.0	10.6	999.0	999.0	656.1	999.0	9999.0	49.5
057	012	308.0	6.0	308.0	15.6	999.0	999.0	661.8	999.0	9999.0	22.2
057	054	350.0	8.0	316.0	15.5	999.0	999.0	661.7	999.0	9999.0	19.2
058	012	387.0	8.0	315.0	15.6	65.8	8.3	661.8	663.6	9999.0	8.6
058	054	429.0	.0	.0	999.0	999.0	999.0	999.0	999.0	9999.0	88.8
059	012	238.0	8.0	307.0	15.6	72.6	10.0	661.8	663.7	1006.1	8.5
059	054	280.0	11.0	315.0	15.6	77.5	11.1	661.8	663.8	9999.0	6.0
060	012	133.0	8.0	317.0	16.1	68.1	9.4	662.4	664.3	1008.1	4.8
060	054	175.0	9.0	313.0	16.1	63.9	8.3	662.4	664.2	9999.0	4.9
061	012	516.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
061	054	558.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
064	012	1212.0	11.0	351.0	12.8	999.0	999.0	658.6	999.0	9999.0	5.1
064	054	1254.0	14.0	346.0	12.8	999.0	999.0	658.6	999.0	9999.0	8.0
065	012	2065.0	15.0	222.0	10.6	999.0	999.0	656.1	999.0	9999.0	77.3
065	054	2107.0	1.0	326.0	10.2	999.0	999.0	655.6	999.0	9999.0	7.9
066	012	39.0	9.0	307.0	16.1	72.7	10.6	662.4	664.4	9999.0	8.1
066	054	81.0	10.0	311.0	16.1	999.0	999.0	662.4	999.0	9999.0	6.6
101	012	1089.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
101	054	1131.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
102	012	227.0	10.0	315.0	16.1	999.0	999.0	662.4	999.0	9999.0	8.5
102	054	269.0	11.0	314.0	15.9	999.0	999.0	662.2	999.0	9999.0	6.5
102	102	317.0	12.0	313.0	999.0	999.0	999.0	999.0	999.0	9999.0	5.7
200	012	322.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
200	054	364.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
200	102	412.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
200	204	514.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
300	012	397.0	10.0	342.0	15.0	999.0	999.0	661.2	999.0	9999.0	6.8
300	054	439.0	12.0	347.0	14.6	999.0	999.0	660.7	999.0	9999.0	6.8
300	102	487.0	14.0	277.0	14.8	999.0	999.0	661.0	999.0	9999.0	5.4
300	108	493.0	14.0	339.0	999.0	999.0	999.0	999.0	999.0	9999.0	5.0
300	204	589.0	16.0	331.0	14.6	999.0	999.0	660.7	999.0	9999.0	3.8
300	300	685.0	16.0	347.0	14.3	999.0	999.0	660.4	999.0	9999.0	3.0
301	012	392.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	054	434.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	102	482.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	204	584.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0
301	300	680.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	9999.0	999.0

DASS DATA FROM BLDG. DAS1, UNEDITED

24/10/97 03:00 10-MIN. AVE.

ALT M	DIR DEG	V KNOTS	VZ KNOTS	SD DEG	SV KNOTS	SZ KNOTS
GND	269	3.3	.4	.4	1.0	.4
50	--	--	--	--	--	--
100	--	--	--	--	--	--
150	318	15.6	-.4	3.4	.6	.4
200	317	16.5	-.4	3.2	.6	.4
250	316	16.9	-.6	3.3	.8	.6
300	315	17.7	-.6	3.7	1.0	.6
350	316	17.9	-.8	3.7	1.0	.8
400	314	18.3	-1.4	3.8	1.2	.8
450	311	17.7	-1.7	3.6	1.0	1.0
500	311	18.5	-1.7	3.5	1.0	1.0
550	311	17.9	-1.9	3.6	1.0	1.0
600	316	16.9	-1.9	4.0	1.0	1.0

650	316	16.5	-2.1	4.4	1.2	1.0
700	321	16.3	-1.7	4.3	1.2	.8
750	323	16.3	-1.6	4.3	1.2	.8
800	328	15.6	-1.0	4.4	1.0	.8
850	330	15.6	-.8	4.1	1.0	.8
900	331	16.3	-.4	3.8	.8	.6
950	329	18.3	-.4	3.6	1.0	.4
1000	325	20.6	-.6	3.2	1.0	1.0

DASS DATA FROM BLDG. DAS2, UNEDITED

24/10/97 02:50 10-MIN. AVE.

ALT M	DIR DEG	V KNOTS	VZ KNOTS	SD DEG	SV KNOTS	SZ KNOTS
GND	316	8.2	.8	5.6	1.2	.4
50	130	1.6	.2	95.9	.4	2.1
100	46	14.8	--	--	--	--
150	--	--	3.3	--	--	--
200	--	--	--	--	--	--
250	--	--	--	--	--	--
300	--	--	--	--	--	--
350	--	--	4.1	--	--	1.4
400	--	--	3.7	--	--	1.6
450	--	--	3.9	--	--	2.3
500	--	--	5.2	--	--	1.0
550	--	--	4.1	--	--	.8
600	--	--	6.2	--	--	--
650	--	--	3.9	--	--	.8
700	38	2.5	1.7	--	--	1.2
750	--	--	1.7	--	--	--
800	--	--	3.1	--	--	.8
850	--	--	--	--	--	--
900	--	--	1.4	--	--	.8
950	--	--	5.1	--	--	--
1000	--	--	3.1	--	--	--

DASS DATA FROM BLDG. DAS3, UNEDITED

24/10/97 03:00 10-MIN. AVE.

ALT M	DIR DEG	V KNOTS	VZ KNOTS	SD DEG	SV KNOTS	SZ KNOTS
GND	318	9.3	.2	1.3	1.2	.6
50	238	3.1	-.6	71.8	4.3	4.5
100	343	9.7	.0	57.7	6.8	4.7
150	14	1.7	.6	99.1	.2	2.1
200	50	19.6	.4	100.2	4.3	1.2
250	24	21.8	.2	68.9	20.2	.6
300	--	--	.8	--	--	1.6
350	--	--	3.1	--	--	2.1
400	--	--	2.7	--	--	1.6
450	--	--	-10.5	--	--	--
500	106	5.2	-10.7	--	--	--
550	336	39.7	-2.3	5.5	.4	5.8
600	51	16.9	-2.7	--	--	6.2
650	--	--	-5.4	--	--	6.0
700	--	--	-4.7	--	--	7.8
750	184	37.1	-1.9	--	--	1.9
800	--	--	2.1	--	--	--
850	259	47.4	2.1	33.4	3.1	--

900	--	--	1.9	--	--	--
950	--	--	-.6	--	--	3.1
1000	116	20.0	-2.1	--	--	3.1

DASS DATA FROM BLDG. DAS4, UNEDITED

24/10/97 02:50 10-MIN. AVE.

ALT M	DIR DEG	V KNOTS	VZ KNOTS	SD DEG	SV KNOTS	SZ KNOTS
GND	323	2.5	.2	2.6	.2	--
50	331	7.6	-.8	6.5	.8	.6
100	330	7.2	-1.2	8.0	.8	.4
150	326	10.3	-.8	5.1	.6	.4
200	325	8.6	-1.0	6.6	.8	.8
250	317	8.9	-.8	6.2	.8	.8
300	319	8.4	-1.2	6.3	.6	1.2
350	315	8.7	-1.2	6.0	.6	1.2
400	315	8.9	-1.0	5.8	.6	1.2
450	320	7.0	-1.4	7.6	.6	1.4
500	311	10.7	-.6	5.6	.8	.4
550	--	--	--	--	--	--
600	--	--	--	--	--	--
650	--	--	--	--	--	--
700	--	--	--	--	--	--
750	--	--	--	--	--	--
800	--	--	--	--	--	--
850	--	--	--	--	--	--
900	317	7.2	-1.9	7.8	.8	1.9
950	320	16.1	-1.0	3.6	.8	1.4
1000	326	15.6	-1.4	3.8	.8	1.4